U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS—MILTON WHITNEY, Chief.

REPORT ON A RECONNOISSANCE OF THE SOILS, AGRICULTURE, AND OTHER RESOURCES OF THE KENAI PENINSULA REGION OF ALASKA.

BY

HUGH H. BENNETT.

[Advance Sheets—Field Operations of the Bureau of Soils, 1916.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., October 20, 1917.

SIR: During the field season of 1916 a reconnoissance soil survey was made of the Kenai peninsular region of Alaska. The manuscript report and maps covering the work are now submitted, with the recommendation that they be published as advance sheets of the report on the field operations of the Bureau of Soils, 1916, as authorized by law.

Very respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

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REPORT ON A RECONNOISSANCE OF THE SOILS, AGRICULTURE, AND OTHER RESOURCES OF THE KENAI PENINSULA REGION OF ALASKA.

By HUGH H. BENNETT.

INTRODUCTION.

In the summer of 1916 a reconnoissance of the Kenai Peninsula of Alaska was made by a party composed of scientists from the Forest Service and Bureau of Soils[1] for the purpose of studying the soils, agriculture, and other resources and the general economic conditions of the region within and adjacent to the Chugach National Forest. (Pl. A and fig. 1.) The Chugach Forest comprises within its boundaries 5,532,615 acres of land, situated in the coast region between Cook Inlet on the west and Cape Suckling on the east, and including Afognak Island, about 50 miles southwest of the southern end of Kenai Peninsula. Not all of the area in this region is included in the Chugach Forest. There are town-site, military, and other reservations; the southern portion of the Kenai Mountains is not included; and a large part of the Kenai lowlands, that lying between a strip 3 miles wide skirting Cook Inlet from the head of Kachemak Bay to East Foreland and a line extending along the crest of the Kenai Mountains from Sheep Creek to about the head of Upper Russian Lake, thence by Russian River to Kenai River, and thence north to the latitude of East Foreland, was eliminated in 1915.[2] The entire Kenai Peninsula, however, is discussed in this report, that part lying outside the forest reserve as well as that within.

On July 18 the reconnoissance party, with Keith McCulloch, forest ranger stationed at Anchorage, left Anchorage on a gasoline launch (the *Wilhelmina*), and between this date and July 29 cruised along the shore of Cook Inlet from Moose Point to the head of Turnagain Arm, making trips inland on foot at Moose Point, Miller Creek,

[1] A. C. Ringland and L. Wernstedt, of the Forest Service, and Hugh H. Bennett, of the Bureau of Soils, U. S. Department of Agriculture, assisted from time to time by other men from the Forest Service.

The soil mapping in the Knik Arm strip was done by Thomas M. Hunt and Asher Ireland, of the Forest Service, and that in the Kachemak Bay-East Foreland strip by L. Wernstedt and A. Nilsson, of the Forest Service.

[2] Elimination of two additional tracts has beeen proposed and is pending. These are the Ship Creek area of approximately 109,300 acres situated along Knik Arm in the vicinity of Anchorage, and the other comprising the 3-mile strip of National Forest land along Kachemak Bay and Cook Inlet, situated between Fox River and Kasilof River, amounting to 198,500 acres.

Point Possession, up Chickaloon and Big Indian Rivers, at Burnt Island, Hope, Sunrise, Bird Creek, Glacier Creek, Kern Creek, and Potter Creek. The party returned to Anchorage July 29, and thereafter spent several days in studying the strip east of Knik Arm and the Matanuska Valley. On August 6 they again left Anchorage on the *Wilhelmina* and made investigations at a number of points on Kenai Peninsula between Point Possession and the head of Kachemak Bay, including Nikishka, Kenai, Kasilof, Ninilchik, Anchor Point, Fritz and Fox Creeks, Bear Cove, and Seldovia, returning to Anchorage August 17.

The party then proceeded by steamer to Seward, from which place several trips were made. On August 23 the party went over the Government railroad from Seward to Spencer Glacier, returned to Roosevelt, on Kenai Lake, and the following day went by boat to the lower end of Kenai Lake, making several stops on the way. On August 25 the trip was made down Kenai River in a small river boat to Bill Kaiser's cabin on Skilak Lake, with Walter Lodge and Louis Bell as assistants. A number of trips back into the mountains and lowlands were made from Skilak Lake and Kenai River, which water route affords a convenient way of crossing Kenai Peninsula from the head of Kenai Lake to the village of Kenai, about 107 miles, by river, to the west, on Cook Inlet.

The principal trips made back from this water route were: (1) Up Cottonwood Creek through the Kenai Mountains to a point on Kings County Creek near the foot of the mountains, thence back into the mountains to Benjamin Creek and up the valley of this stream, thence back through Bear Pass to Cottonwood Creek and Skilak Lake; (2) about 6 miles southwestward from the mouth of King County Creek; (3) about 6 miles northeastward from Kenai River near its confluence with Killey River; (4) 5 miles up Moose River; and (5) from the big southerly bend in Kenai River below Moose River southward nearly to the lower end of Tustumena (or Kasilof) Lake. Returning to Kenai River we proceeded by that stream to Kenai, arriving there September 4.

Following this the party proceeded to Cordova, from which point a trip was made into the Copper River delta. On September 18 the party sailed from Cordova for southern Alaska. A few days were spent at Juneau, studying agriculture and dairying in that vicinity, and then the party returned to Portland, Oreg., where a conference was held regarding the summer's work, and where it was decided to prepare a report on the work accomplished.

It is seen from this itinerary that most of the time was spent on the Kenai Peninsula. This was done because the Kenai lowland, on account of its smoother topography obviously possesses greater possibilities for farming than the remaining, mainly mountainous, por-

tion of the regions, because the Kenai lowland is less well known, and finally because the weather conditions had become unfavorable for satisfactory work by the time a few investigations had been made in the Prince William Sound country. Several stops were made in Prince William Sound at Latouche, Valdez, and Ellamar, where brief investigations were made.

No stop was made on Afognak Island, but our ship passed very close to shore along the southern side of the island, and one member of the party (Wernstedt) had spent considerable time on the island making a topographic map. Nearly a day was spent on the neighboring island—Kodiak.

This report, therefore, deals principally with the Kenai Peninsula, though touching also on the Knik Arm strip and the Prince William Sound region.

CLIMATE.

The climate of the Kenai Peninsula-Prince William Sound region is characterized by moderately warm summers and by winters that are mild for the latitude, especially in the coastal zone. Temperature is moderated here, as along the entire southern coast of Alaska, by warm ocean currents, commonly referred to as the Japan Current. There is much variation of climate from the coast toward the interior, particularly in precipitation and in winter temperature. Toward the interior of Alaska the precipitation is much lighter, and much colder temperatures are experienced. So rapid is the change that the region under discussion may be considered as having two climatic zones: (1) A maritime or wet, mild winter zone and (2) an intermediate or moderately dry, moderately cold winter zone. The intermediate zone lies just back of the coast country, but on the seaward side of the crests of the Alaska Range. It embraces the country contiguous to Cook Inlet above its mouth, and could as well be designated the Cook Inlet climatic zone. It is much drier than most of the country immediately bordering the Pacific Ocean, although not so dry as the transmountain or interior Alaska country with its severe continental climate. Some of the arms or fiords of the Pacific reaching far back into the mountains may have about their interior extremities a climate approximating that of Cook Inlet.

As regards the temperatures of summer, while there is not much difference between the mean temperature of the coast country under discussion and that of the interior of Alaska, the highest temperatures recorded are those of the interior, as at Fort Yukon, just north of the Arctic Circle, where in 1915 a temperature of 100° F. was reached.

Tables compiled from the records of seven stations in or near by the Kenai Peninsula and Prince William Sound region are given in

succeeding pages of this report. These stations are Seward, Sunrise, Kenai, Fort Liscum, Tyonek, Cordova, and Valdez.

In addition similar tables have been compiled also for Sitka, in the southern coast region, Kodiak, lying out in the Pacific southwest of the Kenai Peninsula, and for Nome, in the northern coast region, for Copper Center, about 50 miles north of Valdez, and for Fairbanks, in the interior of Alaska about 325 miles north of Seward. The records of these latter stations are presented to enable a comparison of the climatic conditions in the areas discussed in this report with those of other coastal regions and of interior Alaska.

The mean annual temperature for the stations on and around the Kenai Peninsula range from 33.3° F. at Kenai to 41.2° F. at Cordova. The absolute maximum temperatures for the same group of stations range from 91° F. at Tyonek, lying across Cook Inlet from the Peninsula, to 79° F. at Sunrise, situated on the Peninsula about 50 miles north of Seward. The annual mean for Fairbanks, situated in interior Alaska, is very much lower, being 25.6° F., and the absolute maximum is higher, or 95° F. The absolute minimum for the Kenai group of stations ranges from 1° above zero at Cordova to —46° at Tyonek. During a period of 11 years the absolute minimum at Fairbanks was —65° F.

It will be noted that there is considerable uniformity between the annual mean temperatures of the Kenai group of stations, but that no such uniformity exists in precipitation. The mean annual rainfall ranges from 18.95 inches at Kenai to 132.96 inches at Cordova, while the absolute maximum ranges from 22.51 inches at Kenai to 190.83 inches at Cordova. The mean annual precipitation in interior Alaska as represented by the records of Fairbanks is 11.71 inches, and the absolute maximum 18.73 inches.

It it interesting, in this connection, to compare the climate of Cordova at 60° 30′ north latitude with that of Washington, D. C., situated practically at 39° north latitude or about 1,500 miles farther south. The coldest temperature recorded at Washington is —15° F., or 16 degrees lower than for Cordova; its mean winter temperature is 34.5° F., or only 3 degrees warmer than Cordova, and the precipitation for the wettest year recorded is 61.3 inches, as against 190.83 inches at Cordova. Other interesting comparisons may be drawn from the tables submitted.

The chief factors influencing the climate of the area under discussion are the relatively warm waters of the Pacific coast currents, the mountain barriers of the coast ranges, and the long hours of daylight in summer. Moisture-laden winds from the Pacific impinging against the cool mountains produce the copious rains that characterize the coastal or maritime zone. There are also local variations in the climate which are attributable to such factors as the sur-

rounding topography and proximity to glaciers. In places the sunlight is partially shut off by intervening mountains, and cool winds often sweep through the mountain passes and down from glaciers to chill the surrounding atmosphere. Thus, for example, frost occurred this year (1916) on the low benches at the lower end of Kenai Lake on the night of August 22, damaging potato vines; whereas, no evidence of frost was seen in the open Kenai lowlands up to the time of leaving on September 5. During the period subsequent to this frost we were several times at elevations even greater than the low bench at the lower end of Kenai Lake, where we had seen frost, but not so closely shut in by mountains as the lake.

Turnagain Arm, which is a deep fiord penetrating far into the Chugach-Kenai Mountains, and the flats below the large glaciers, as in the case of Grewingk, Spencer, and Valdez, seem to have a cooler environment than similar flats not so close to glaciers.

Cooler temperatures are encountered at the higher elevations, of course, as is so distinctly shown by the dwarfing of vegetation with increase in elevation above certain levels, and the absolute disappearance of vegetation at about 4,000 feet above sea level, in case of the Cook Inlet region.

The most marked seasonal variations of the Kenai lowland country are represented in the characteristic light precipitation of the winter and spring months and June, and the relatively heavy precipitation for July, August, and September. Rains here come in the form of both intermittent, moderately heavy showers and as long-continued drizzling rains with intervening periods of cloudy weather. There are many sunny days, from one-third to one-half of the days being clear, or partly so, on upper Cook Inlet. Some years are characterized by cloudy, rainy summers. The summer of 1912 is said to have been a season of much rain and cloudy weather throughout the Cook Inlet-Susitna country. On the other hand, there are years when nearly the entire summer is a season of cloudless skies, as was the summer of 1915. It is a common saying in this part of Alaska that "no two seasons are alike," meaning that no two consecutive summers or winters are alike. The same can be said of the humid portion of the United States, or perhaps of any region, except portions of the Tropics and some arid regions. But apparently there are greater variations here than in the eastern part of the United States. From the standpoint of the farmer the dry summers are much to be preferred in the Cook Inlet region. Crops are sometimes dwarfed as the result of drought, particularly on the shallow soils, but as a rule they do not suffer severely, perhaps on account of the slow evaporation in this cool climate, and they are much more apt to mature in dry seasons than in wet.

In the typical coastal or maritime climatic zone, as that of Prince William Sound, there are fewer sunny days. Rains come in torrents, often continuing for days without interruption. So heavy and so frequent are the rains in the Prince William Sound region that the ground is moist or saturated the greater part of the year, so that fires are not apt to do much, if any, damage, whereas in the Cook Inlet country, dry seasons, when fires do much damage, are common.

The average number of clear days at Fort Liscum is 119; at Cordova, 91 days; at Kenai, 134 days; at Tyonek, 171 days; and at Seward, 144 days.

Notwithstanding the fact that the temperature sometimes rises to 90° F. in the Cook Inlet country, the summer weather characteristically is moderately cool, the June-July-August mean being only 51.8° F. and 52.6° F. at Sunrise and Seward, respectively. The nights are chilly enough for blankets, and after 10 o'clock at night and on cloudy days overcoats usually are comfortable.

Ground ice was found within the 3-foot soil section in a few places on the Kenai lowlands where there was a considerable cover of moss and in muskeg as late as the latter part of August. Elsewhere in the lowlands, congealed material was not reached within this depth, no ice being found in any of the open places or in those places where there was little moss or other vegetable covering.

Ground ice is not a feature of material importance so far as affecting crops. In the first place it very seldom is found as late as July, and when it does occur, it will disappear or melt below the level of winter freezing when the land is cleared and the moss removed. Even where it is present in a cultivated field, as it may be for some time in spring, it may not be counted a hindrance to the growth of vegetation. In the interior of Alaska, as in the farming country about Fairbanks, the presence of ice within 3 feet of the surface is not considered a deleterious soil feature—indeed, it is rather looked upon as an advantage because, on thawing, it gradually releases moisture for the crops.[1] The presence of ground ice late in spring and cold subsoil temperature may have something to do with the characteristic shallow root systems of the trees of this region.

The climate of this region is favorable to a rapid growth of vegetation, the long hours of sunlight having much to do with this. Grass starts in early May, as soon as the snow is melted, and often begins to head by the middle of June. On southward-facing slopes early varieties of oats will begin to head by the middle of June, if seeded early on the well-drained soil of the region—the Knik loam or silt

[1] See Soil Reconnoissance in Alaska, Field Operations of the Bureau of Soils, U. S. Department of Agriculture, 1914.

loam. The growing season, including the planting season, ranges from about May 1 to about September 10, although there may be an occasional frost in the early and late parts of this period. The growing season at Seward has ranged from 146 to 177 days, with a period of 135 days without frost. The usual growing season is from the middle of May to the first week in September, or about 110 days, according to records of the Weather Bureau.

In an earlier report published by the Bureau of Soils[1] the authors state:

> It can be safely asserted that the average growing season is sufficient for the maturing of potatoes, the early varieties of small grains, grass, and a large number of vegetables and small fruits. Grain for hay can be produced every year, even in those localities subject to unseasonable frosts. It is advisable to start crops as early in the spring as possible and to grow the early-maturing varieties. Potatoes can be sprouted indoors before planting, and cabbage, cauliflower, and other plants can be started in a hothouse and transplanted. As a rule, the last frost in the spring and the first in the fall are light and do little damage to ordinary crops. Potatoes are usually not thoroughly matured when struck by frosts, but it is a common practice to leave them in the ground for several weeks, and, while this practice is not favored in warmer climates, many state that the frostbitten vines do not injure the tubers.

While the winters along the coast are mild as compared with those of the interior at the same latitude, they are, nevertheless, sufficiently cold for the precipitation to fall largely as snow and to form moderately deep accumulations of snow, usually from 3 to 5 feet. It is in winter that one can travel to best advantage through the lowland country of this region. At this time the lakes, streams, and boggy muskegs are frozen over, and the brushy undergrowth and grass are buried beneath the snow, so that rapid progress can be made on foot or with dog sleds, where in summer the travel would be very slow and laborious. Most of Cook Inlet is free from ice during the entire winter, except floating ice; but the northern end usually is sufficiently choked with floating ice to hinder navigation between the middle of November and the first of April, and the extreme upper part is closed to navigation by ice for a part of each year.

In the tables following are given climatic data furnished by the Weather Bureau for the following stations: Seward, Sunrise, Kenai, Tyonek, Fort Liscum, Valdez, Cordova, Sitka, Kodiak, Nome, Copper Center, and Fairbanks. These data are given for stations covering a wide range of territory to enable comparison of the climate of the area studied with other parts of Alaska.

[1] Bennett, Hugh H., and Rice, T. D., Soil Reconnoissance in Alaska, Bureau of Soils, U. S. Department of Agriculture, p. 32, 1914.

Normal monthly, seasonal, and annual temperature and precipitation at Seward.

[Length of record, 7 years.]

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow average depth.
	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	26.8	53	−10	8.37	4.91	4.99	17.2
January	22.2	48	−11	3.20	3.32	7.09	16.7
February	28.2	55	−12	5.00	4.52	3.73	15.2
Winter	25.7	55	−12	16.57	12.75	15.81	49.1
March	32.7	67	− 7	4.00	2.50	9.67	8.3
April	37.1	65	10	4.47	.55	11.96	3.9
May	44.8	77	26	3.00	1.43	.10	0
Spring	18.2	77	− 7	11.47	4.48	21.73	12.2
June	50.0	84	32	2.44	2.59	1.71	0
July	55.7	88	40	2.32	2.15	.94	0
August	54.5	85	33	6.45	2.45	12.71	0
Summer	53.4	88	32	11.21	7.19	15.36	0
September	49.3	84	27	7.04	7.12	9.46	0
October	39.7	64	11	8.20	5.72	2.82	.4
November	30.7	58	5	6.58	1.55	6.24	4.2
Fall	19.9	84	5	21.82	14.39	18.52	4.6
Year	39.3	88	−12	61.07	38.81	71.42	65.9

Normal monthly, seasonal, and annual temperature and precipitation at Sunrise.

[Length of record, 11 years.]

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow average depth.
	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	23.9	48	−26	4.91	3.36	8.48	27.4
January	16.9	44	−29	2.43	.54	2.12	22.9
February	27.7	51	−27	2.65	1.05	1.93	14.8
Winter	22.8	51	−29	9.99	4.95	12.53	65.1
March	32.9	58	−23	1.72	2.71	1.64	15.8
April	41.0	59	− 4	2.54	.68	3.41	8.8
May	51.7	76	20	1.96	2.27	.84	T.
Spring	41.9	76	−23	6.22	5.66	5.89	24.6
June	58.7	79	27	1.18	1.96	.69	0
July	61.2	76	34	1.98	1.79	1.40	0
August	59.3	78	28	3.15	3.06	4.46	0
Summer	59.7	79	27	6.31	6.81	6.55	0
September	51.3	72	17	3.26	2.64	1.86	.9
October	41.1	59	2	4.91	2.56	4.36	5.2
November	28.7	51	−15	4.61	.40	9.47	16.8
Fall	40.4	72	−15	12.78	5.60	15.69	22.9
Year	41.2	79	−29	35.30	23.02	40.66	112.6

Normal monthly, seasonal, and annual temperature and precipitation at Kenai.

[Length of record, 24 years.]

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow average depth.
	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	12.7	45	−43	1.02	0.19	1.41	10.1
January	10.3	49	−42	.65	.64	.29	7.3
February	18.3	48	−46	1.01	.07	4.92	10.0
Winter	13.8	49	−46	2.68	.90	6.62	27.4
March	24.2	59	−34	.83	.32	.57	7.0
April	33.9	68	−17	.65	.85	.46	3.3
May	43.7	79	−20	.85	.30	.84	T.
Spring	33.9	79	−34	2.33	1.47	1.87	10.3
June	49.6	87	28	.92	.06	.84	0
July	53.6	82	27	2.16	1.66	1.06	0
August	53.9	79	25	3.39	4.85	6.26	0
Summer	52.4	87	25	6.47	6.57	8.16	0
September	46.0	89	11	3.06	2.23	.78	0
October	32.4	60	− 5	2.29	1.69	2.92	4.5
November	21.1	46	−27	2.12	.64	2.16	9.4
Fall	33.2	89	−27	7.47	4.56	5.86	13.9
Year	33.3	89	−46	18.95	13.50	22.51	51.6

Normal monthly, seasonal, and annual temperature and precipitation at Tyonek.

[Length of record 11 years.]

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	18.5	49	−21	1.21	1.54	1.72	13.2
January	11.5	38	−27	1.68	2.69	3.08	16.9
February	18.6	49	−25	.98	.52	.52	12.6
Winter	16.2	49	−27	3.87	4.75	5.32	42.7
March	25.3	58	− 9	.91	.47	1.09	13.2
April	35.2	59	− 1	.99	.60	.71	10.4
May	45.2	74	22	.46	.29	.38	.7
Spring	35.2	74	− 9	2.36	1.36	2.18	24.3
June	53.4	91	33	1.05	.72	0	0
July	57.0	82	38	2.66	1.05	2.93	
August	58.3	76	31	4.41	4.94	5.40	0
Summer	56.2	91	31	8.12	6.71	8.33	0
September	48.9	79	22	3.82	4.22	6.56	0
October	36.2	61	5	3.37	2.53	4.96	5.2
November	25.2	47	−13	1.27	.60	.94	9.9
Fall	36.8	79	−13	8.46	7.35	12.46	15.1
Year	36.1	91	−27	22.81	20.17	28.29	82.1

Normal monthly, seasonal, and annual temperature and precipitation at Fort Liscum.

[Length of record, 14 years.]

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	23.8	45	−13	8.56	6.22	7.53	80.1
January	19.6	45	−14	6.77	1.98	9.40	79.3
February	22.3	45	−12	5.00	5.11	.80	54.1
Winter	21.9	45	−14	20.33	13.31	17.73	213.5
March	26.6	54	− 8	5.80	4.27	6.38	64.5
April	33.9	53	2	4.15	5.08	6.20	34.6
May	42.8	71	25	3.90	3.15	1.45	1.2
Spring	34.4	71	− 8	13.85	12.50	14.03	100.3
June	50.3	79	27	2.50	2.99	1.13	0
July	52.8	83	32	4.65	5.60	4.77	0
August	50.5	80	30	8.05	2.59	16.20	0
Summer	51.2	83	27	15.20	11.18	22.10	0
September	45.3	84	17	8.91	5.71	12.72	1.2
October	35.6	60	10	8.56	8.01	10.31	11.0
November	25.3	47	0	6.11	2.21	6.28	46.5
Fall	35.4	84	0	23.58	15.93	29.31	58.7
Year	35.7	84	−14	72.96	52.92	83.17	372.5

Normal monthly, seasonal, and annual temperature and precipitation at Valdez.

[Length of record, 6 years.]

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.
	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*
December	21.4	45	− 8	7.51	3.82	9.14
January	19.3	44	−17	3.56	.41	3.04
February	22.6	47	− 9	5.04	3.54	4.97
Winter	21.1	47	−17	16.11	7.77	17.15
March	27.1	52	− 6	4.63	2.85	10.97
April	34.1	63	4	3.72	3.93	.71
May	44.0	78	18	2.81	1.88	5.45
Spring	35.1	78	− 6	11.16	8.66	17.13
June	51.8	78	30	2.16	4.08	1.23
July	54.4	84	37	3.14	2.79	5.10
August	52.2	84	29	5.11	8.96	7.05
Summer	52.8	84	29	10.41	15.83	13.38
September	47.1	82	23	7.64	4.31	18.74
October	38.1	62	11	5.25	5.05	6.99
November	25.6	53	− 4	2.95	3.11	2.47
Fall	36.9	82	− 4	15.84	12.47	28.20
Year	36.5	84	−17	53.52	44.73	75.86

Normal monthly, seasonal, and annual temperature and precipitation at Cordova.

[Length of record, 5 years.]

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	31.0	47	5	15.90	9.33	13.47	42.4
January	29.0	52	5	5.84	8.89	10.00	30.3
February	33.0	58	4	9.75	7.50	12.21	29.9
Winter	31.0	58	4	31.49	25.72	35.68	102.6
March	34.0	62	1	10.72	16.18	16.79	23.6
April	37.6	71	15	7.90	5.34	4.02	24.0
May	44.9	70	28	8.62	6.21	20.29	.3
Spring	38.8	71	1	27.24	27.73	41.10	47.9
June	50.6	76	34	7.80	5.82	5.66	0
July	54.8	87	40	6.90	7.51	4.99	0
August	54.3	75	40	12.10	6.39	23.16	0
Summer	53.2	87	34	26.80	19.72	33.81	0
September	49.7	78	32	22.35	12.61	49.63	T.
October	42.1	72	27	16.92	19.70	24.88	.7
November	33.6	60	12	8.16	6.37	5.73	15.4
Fall	41.8	78	12	47.43	38.68	80.24	16.1
Year	41.2	87	1	132.96	111.85	190.83	166.6

Normal monthly, seasonal, and annual temperature and precipitation at Fairbanks.

[Length of record, 11 years.]

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	− 5.8	43	−59	0.81	0.75	0.59	9.9
January	−16.4	34	−65	.76	.42	3.30	8.5
February	− .5	43	−57	.37	.21	.86	5.1
Winter	− 7.2	43	−65	1.94	1.38	4.75	23.5
March	11.0	56	−56	.77	1.10	2.42	8.0
April	28.4	64	−32	.30	.03	.03	2.5
May	48.1	81	5	.44	.52	.35	T.
Spring	29.2	81	−56	1.51	1.65	2.80	10.5
June	59.2	95	31	1.57	.96	1.47	0
July	60.8	88	30	1.61	.73	1.51	0
August	53.9	85	17	2.02	.71	1.81	0
Summer	58.0	95	17	5.20	2.40	4.79	0
September	42.1	80	10	1.53	1.57	3.58	.6
October	25.2	67	−21	.65	.47	2.46	5.2
November	1.7	46	−54	.88	.51	.35	5.4
Fall	23.0	80	−54	3.06	2.55	6.39	11.2
Year	25.6	95	−65	11.71	7.98	18.73	45.2

Normal monthly, seasonal, and annual temperature and precipitation at Copper Center.

[Length of record, 12 years.]

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	− 3.3	50	−53	0.61	0.70	0.35	8.2
January	−11.4	49	−74	.56	.45	1.14	6.5
February	2.5	49	−55	.51	.25	.19	3.8
Winter	− 4.1	50	−74	1.68	1.40	1.68	18.5
March	13.6	49	−48	.26	.05	.69	2.9
April	29.1	67	−26	.11	.10	.36	1.0
May	45.0	80	17	.43	.13	.43	T.
Spring	29.2	80	−48	.80	.28	1.48	3.9
June	54.2	96	21	.86	.27	1.19	0
July	56.1	88	22	1.56	1.83	2.14	0
August	53.2	87	20	1.10	.65	.69	0
Summer	54.5	96	20	3.52	2.75	4.02	0
September	43.1	80	3	1.22	.78	.37	.7
October	28.9	66	−26	.96	1.15	.84	7.6
November	5.4	49	−46	.87	.10	.99	7.9
Fall	25.8	80	−46	3.05	2.03	2.20	16.2
Year	26.4	96	−74	9.05	6.46	9.38	38.6

Normal monthly, seasonal, and annual temperature and precipitation at Sitka.

Month.	Temperature.			Precipitation.			
	Mean.[1]	Absolute maximum.[2]	Absolute minimum.[2]	Mean.[3]	Total amount for the driest year.[3]	Total amount for the wettest year.[3]	Snow, average depth.[4]
	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	35.7	59	5	8.92	5.97	3.26	8.6
January	31.9	56	−4	7.59	4.84	7.36	15.7
February	34.0	58	−3	6.54	2.07	18.84	10.0
Winter	33.8	59	−4	7.68	12.88	29.46	34.3
March	36.9	65	−1	5.73	5.89	10.08	6.6
April	41.4	70	15	5.65	3.14	7.67	8.1
May	46.9	80	28	4.07	3.18	3.68	T.
Spring	41.7	80	−1	5.15	12.21	21.43	14.7
June	51.3	84	30	3.38	3.70	4.53	0
July	54.8	87	34	4.26	2.51	3.27	0
August	55.5	83	30	6.12	2.65	10.72	0
Summer	53.8	87	30	4.58	8.86	18.52	0
September	51.7	80	28	9.94	6.13	25.52	0
October	45.9	70	22	11.75	8.85	24.82	T.
November	38.1	60	1	9.42	6.58	20.51	2.0
Fall	44.9	80	1	10.37	21.56	70.85	2.0
Year	43.7	87	−4	83.37	58.21	140.26	51.0

[1] Length of record 1867 to 1915 incomplete.
[2] Length of record 1872 to 1877, 1881 to 1887, 1898 to 1915.
[3] Length of record 1842 to 1915.
[4] Length of record 1899 to 1915.

Normal monthly, seasonal, and annual temperature and precipitation at Kodiak.

[Length of record, 46 years.]

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	30.8	61	−12	8.44	5.47	9.41	7.3
January	29.5	53	− 8	5.12	1.33	3.45	9.3
February	31.2	58	− 3	4.66	1.53	5.08	9.2
Winter	30.5	61	−12	18.22	8.33	17.94	25.8
March	34.0	65	2	4.14	3.92	1.23	10.0
April	36.2	61	5	3.89	5.41	.09	8.9
May	43.7	74	20	5.60	4.97	9.94	.6
Spring	37.9	74	2	13.63	14.30	11.86	19.5
June	50.5	82	30	4.68	7.25	7.25	T.
July	54.9	82	32	3.42	2.92	4.20	0
August	55.0	85	35	5.01	5.12	8.45	0
Summer	53.4	85	30	13.11	15.29	19.90	T.
September	50.0	77	26	5.69	4.64	7.59	.1
October	41.5	66	16	7.37	4.45	17.83	.7
November	35.1	54	9	5.98	1.42	8.53	3.2
Fall	42.2	77	9	19.04	10.51	33.95	4.0
Year	41.0	85	−12	64.00	48.43	83.65	49.3

Normal monthly, seasonal, and annual temperature and precipitation at Nome.

[Length of record, 18 years.]

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	7.1	36	−31	1.14	1.22	1.82	12.6
January	3.6	36	−35	.83	.37	.48	10.6
February	5.2	41	−38	.69	.13	.70	7.9
Winter	5.3	41	−38	2.66	1.72	3.00	31.1
March	8.8	36	−38	1.01	.21	.12	9.8
April	18.3	48	−23	.48	.45	.87	3.9
May	35.9	62	− 6	.72	.15	.84	.4
Spring	21.0	62	−38	2.21	.81	1.83	14.1
June	46.1	78	26	.91	.88	1.53	T.
July	50.8	77	30	2.37	.82	3.82	0
August	49.5	74	23	2.65	1.66	1.07	0
Summer	48.8	78	23	5.93	3.36	6.42	T.
September	41.3	66	19	2.25	.96	3.72	.1
October	29.3	46	1	1.24	1.45	.99	2.3
November	16.3	39	−14	1.00	1.16	3.92	10.7
Fall	29.0	66	−14	4.49	3.57	8.63	13.1
Year	26.0	78	−38	15.29	9.46	19.88	58.3

Average number of clear, partly cloudy, and cloudy days, and days with rain or snow.

Month.	Seward, 1911 to 1915, inclusive.				Sunrise, 1910 to 1914, inclusive.			
	Clear.	Partly cloudy.	Cloudy.	Rain or snow.	Clear.	Partly cloudy.	Cloudy.	Rain or snow.
January	15	4	12	9	12	4	15	14
February	9	5	14	13	6	5	17	15
March	14	7	10	12	12	5	14	13
April	14	6	10	13	10	8	12	12
May	12	9	10	10	8	9	14	15
June	12	6	12	8	10	7	13	10
July	13	6	12	10	9	8	14	15
August	10	7	14	16	9	8	14	16
September	10	7	13	15	8	4	18	19
October	12	6	13	15	7	4	20	19
November	13	3	14	12	10	4	16	14
December	10	3	18	15	8	6	17	19
Total	144	69	152	148	109	72	184	181

Month.	Kenai, 1900 to 1904, inclusive.				Fort Liscum, 1911 to 1915, inclusive.			
	Clear.	Partly cloudy.	Cloudy.	Rain or snow.	Clear.	Partly cloudy.	Cloudy.	Rain or snow.
January	13	7	11	7	16	5	10	10
February	11	5	12	5	8	7	13	13
March	15	8	8	4	14	5	12	11
April	10	9	11	6	12	7	11	11
May	14	7	10	4	14	8	9	10
June	13	7	10	5	11	7	12	9
July	11	8	12	10	10	5	16	16
August	7	8	16	16	7	7	17	16
September	13	5	12	14	6	6	18	20
October	6	8	17	10	6	7	18	16
November	9	7	14	6	8	6	16	12
December	12	4	15	7	7	8	16	19
Total	134	83	148	94	119	78	168	163

Average number of clear, partly cloudy, and cloudy days, and days with rain or snow—Continued.

Month.	Valdez, 1911 to 1915, inclusive.				Cordova, 1909 to 1914, inclusive.			
	Clear.	Partly cloudy.	Cloudy.	Rain or snow.	Clear.	Partly cloudy.	Cloudy.	Rain or snow.
January	9	7	15	12	11	6	14	15
February	6	6	16	15	5	8	15	18
March	11	7	13	13	10	9	12	16
April	11	6	13	13	10	9	11	14
May	10	7	14	14	8	10	13	17
June	8	9	13	13	7	12	11	15
July	7	7	17	16	5	7	19	17
August	6	6	19	20	6	9	16	17
September	5	7	18	20	5	8	17	21
October	8	8	15	20	8	8	15	20
November	8	6	16	13	10	4	16	15
December	7	7	17	17	6	3	22	21
Total	96	83	186	186	91	93	181	206

Month.	Fairbanks, 1911 to 1915, inclusive.				Copper Center, 1910 to 1915, inclusive.			
	Clear.	Partly cloudy.	Cloudy.	Rain or snow.	Clear.	Partly cloudy.	Cloudy.	Rain or snow.
January	14	6	11	4	14	7	10	2
February	16	2	10	4	9	10	9	3
March	14	5	12	4	12	14	5	2
April	14	9	7	3	11	15	4	1
May	12	12	7	4	6	20	5	2
June	8	13	9	10	7	17	6	5
July	7	12	12	12	5	18	8	8
August	4	11	16	15	6	19	6	4
September	4	11	15	11	9	10	11	6
October	10	11	10	6	9	11	11	2
November	13	8	9	4	10	10	10	6
December	8	8	15	10	10	5	16	5
Total	124	108	133	87	108	156	101	46

Average number of clear, partly cloudy, and cloudy days, and days with rain or snow—Continued.

Month.	Sitka, 1911 to 1915, inclusive.				Kodiak, 1910 to 1915, inclusive.			
	Clear.	Partly cloudy.	Cloudy.	Rain or snow.	Clear.	Partly cloudy.	Cloudy.	Rain or snow.
January	9	4	18	18	4	14	13	16
February	5	5	18	18	2	14	12	16
March	8	4	19	18	6	16	9	14
April	5	6	19	19	7	12	11	12
May	8	6	17	15	5	16	10	12
June	6	7	17	14	4	15	11	14
July	7	4	20	19	6	17	8	11
August	5	4	22	22	2	15	14	17
September	5	5	20	22	3	20	7	12
October	3	6	22	24	1	16	14	18
November	5	5	20	23	4	15	11	13
December	7	4	20	21	7	11	13	15
Total	73	60	232	233	51	181	133	170

Dates of last freezing temperatures in spring and of the first freezing temperatures in fall.

Station.	1906		1907		1908		1909	
	Last in spring.	First in autumn.	Last in spring.	First in autumn.	Last in spring.	First in autumn.	Last in spring.	First in autumn.
Sunrise	May 30	Sept. 7	May 21	Sept. 2	June 14	Sept. 4	June 21	Sept. 14
Fairbanks	May 15	Aug. 25	May 22	Sept. 1	May 11	Aug. 31	May 15	Aug. 1
Seward	N. R.	N. R.	N. R.	N. R.	May 17	Sept. 25	May 13	Sept. 22
Fort Liscum	May 7	Sept. 24	May 17	Aug. 31	May 10	Aug. 4	May 21	Do.
Sitka	May 6	Nov. 2	May 16	Oct. 15	May 12	Sept. 23	May 14	Oct. 8
Cordova	N. R.	N. R.	N. R.	N. R.	N. R.	N. R.	N. R.	Sept. 25
Valdez	N. R.	N. R.	N. R.	N. R.	N. R.	N. R.	N. R.	N. R.
Kodiak	N. R.	N. R.	N. R.	N. R.	June 13	Sept. 7	May 31	Sept. 21
Nome	N. R.	N. R.	June 28	Aug. 24	June 15	Aug. 7	June 22	Sept. 2

Station.	1910		1911		1912	
	Last in spring.	First in autumn.	Last in spring.	First in autumn.	Last in spring.	First in autumn.
Sunrise	June 18	Sept. 21	June 2	Sept. 15	June 9	[1] Aug. 27
Fairbanks	May 22	Aug. 21	...do....	Aug. 30	...do....	Aug. 27
Seward	May 11	Oct. 4	June 9	Oct. 6	June 5	Sept. 24
Fort Liscum	May 21	Sept. 21	June 3	Sept. 14	May 14	Oct. 1
Sitka	May 10	Oct. 27	May 23	Sept. 22	Apr. 26	Nov. 3
Cordova	May 10	Oct. 9	May 13	Oct. 30	Apr. 22	Oct. 18
Valdez	May 11	Sept. 22	June 1	Oct. 6	May 19	Aug. 25
Kodiak	June 10	...do....	May 30	Oct. 1	N. R.	N. R.
Nome	June 24	Aug. 4	June 15	Aug. 30	June 8	Aug. 31

Dates of last freezing temperatures in spring and of the first freezing temperatures in fall—Continued.

Station.	1913		1914		1915	
	Last in spring.	First in autumn.	Last in spring.	First in autumn.	Last in spring.	First in autumn.
Sunrise	June 3	Aug. 28	June 6	Sept. 6	N. R.	N. R.
Fairbanks	May 23	Aug. 14	May 26	Aug. 18	May 10	Sept. 7
Seward	May 8	Oct. 8	May 23	Sept. 18	Apr. 30	Oct. 9
Fort Liscum	May 9	Sept. 2	Apr. 22	Sept. 1	June 19	Oct. 2
Sitka	May 6	Sept. 1	May 12	Nov. 12	May 1	Oct. 18
Cordova	May 30	Oct. 10	May 18	N. R.	N. R.	N. R.
Valdez	June 1	Aug. 3	May 24	Sept. 1	May 15	Sept. 9
Kodiak	May 10	Oct. 9	May 2	Sept. 18	May 23	Oct. 12
Nome	June 2	Aug. 24	X	X	June 9	Aug. 21

N. R.=No record. X=Freezing temperature every month in the year. [1]=Record incomplete.

The following tables, given for comparison, give the salient climatic data for Billings and Miles City, Mont., the county seats, respectively, of Yellowstone and Custer Counties, two important live-stock counties of the Great Plains region.

Normal monthly, seasonal, and annual temperature and precipitation at Billings.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1914).	Total amount for the wettest year (1915).	Snow, average depth.
	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	27.7	66	−30	0.35	0.22	0.66	3.9
January	22.2	65	−31	.69	.15	.76	7.7
February	24.7	68	−49	.42	.36	.06	7.5
Winter	24.9	68	−49	1.46	.73	1.48	19.1
March	33.7	75	−26	.82	.44	1.07	11.7
April	47.0	91	4	1.20	1.18	.31	4.7
May	56.7	99	20	2.85	1.96	2.86	1.4
Spring	45.8	99	−26	4.87	3.58	4.24	17.8
June	64.7	100	26	2.44	4.31	5.22	T.
July	71.6	112	37	1.06	.87	2.61	0
August	70.0	104	32	1.08	.22	1.37	0
Summer	68.8	112	26	4.58	5.40	9.20	T.
September	60.9	100	21	1.10	1.33	2.42	T.
October	48.5	91	1	1.38	.79	.18	1.5
November	34.6	72	−20	.78	T.	1.00	4.6
Fall	48.0	100	−20	3.26	2.12	3.60	6.1
Year	47.0	112	−49	14.17	11.83	18.52	43.0

Killing frost: Average date last in spring, May 9; average date first in fall, Sept. 20; latest in spring, June 23; earliest in fall, Aug. 28.

Normal monthly, seasonal, and annual temperature and precipitation at Miles City.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1883).	Total amount for the wettest year (1879).	Snow, average depth.
	° F.	° F.	° F.	Inches.	Inches.	Inches.	Inches.
December	21.0	64	−52	0.62	0	0.58	2.8
January	14.5	55	−65	.62	0.18	.26	4.4
February	16.8	68	−49	.56	.11	.69	3.6
Winter	17.4	68	−65	1.80	.29	1.53	10.8
March	28.6	80	−38	.76	.39	.28	8.0
April	44.7	90	−7	1.18	1.37	2.20	1.3
May	56.7	101	17	1.98	2.80	2.75	1.9
Spring	43.3	101	−38	3.92	4.56	5.23	11.2
June	66.0	107	33	2.77	1.27	5.23	0
July	72.9	112	31	1.37	.66	5.90	0
August	71.5	112	32	1.03	1.25	1.84	0
Summer	70.1	112	31	5.17	3.18	12.97	0
September	61.2	102	16	.92	0	.44	.2
October	46.5	94	−5	.76	.84	2.47	1.1
November	30.9	76	−26	.60	.20	.11	3.9
Fall	46.2	102	−26	2.28	1.04	3.02	5.2
Year	44.2	112	−65	13.17	9.07	22.75	27.2

Killing frost: Average date last in spring, May 6; average date first in fall, Sept. 25; latest in spring, May 22; earliest in fall, Sept. 7.

These tables show that colder temperatures are reached in the cattle districts of Montana than on the Kenai Peninsula. Mean summer temperatures, however, are higher in Montana.

GEOGRAPHY.

Kenai Peninsula is a broad area of mountains and lowlands extending into the Gulf of Alaska. It lies in central-southern Alaska, although the extreme southern parts of the Territory, consisting of (1) the mainland (southeastern Alaska) and of (2) the Aleutian Islands (southwestern Alaska), are some 300 and 500 miles, respectively, farther south.

Longitudinally the central part of the peninsula is about midway between extreme southeastern Alaska and the western end of Umnak Island of the Aleutian chain of islands.[1] The southern extremity

[1] The Aleutian Islands extend far west of Umnak Island, Attu Island being less than 200 miles east of the Kamchatka Peninsula of Siberia.

of Kenai is about 780 miles south of Nigaluk on the Arctic Ocean. It is about 630 miles east of East Cape, which is the eastern extremity of Siberia and which is just north of the Arctic Circle on Bering Strait, or about 500 miles north of the southern end of the Kenai Peninsula.

Kenai Peninsula lies between Prince William Sound on the east and Cook Inlet on the west. These two bodies of water represent the major indentations of the Alaska coast, and their inland extremities represent the northernmost part of the Pacific Ocean.

Cook Inlet is a bay about 200 miles long and 75 miles wide, near its mouth, extending inland beyond the coast ranges, while Prince William Sound is a large embayment about 105 miles across both east and west and north and south, from which numerous fiords reach far back into the mountains.

The peninsula lies between the meridians 148° and 152° west longitude and the parallels 59° and 62° north latitude. Its maximum width from East Foreland on the west side to Prince William Sound is 110 miles, and its greatest length from the southern tip on Port Chatham to the head of Turnagain Arm is 152 miles. The peninsula is connected with the mainland by only a narrow strip, about 9 miles across, between the heads of Turnagain Arm and Passage Canal (or Portage Bay).

If the northern end of the peninsula is taken as lying along a line connecting the heads of Knik Arm and College Fiord, which are the inland extremities of Cook Inlet and Prince William Sound, respectively, the area of the peninsula would be approximately 11,402 square miles. The area south of a line connecting Turnagain Arm and Portage Bay, which in this report will be considered as the Kenai Peninsula proper, is about 9,192 square miles,[1] exclusive of the areas of Tustumena, Skilak, and Kenai Lakes.

The southern extremity of Kenai Peninsula is 1,384 statute miles northwest of Seattle.[2]

The steamship sailing routes between these points, however, are not straight, the ships passing through the winding passages and straits of the "inside passage" for a large part of the distance. By these routes Anchorage is between 2,000 and 2,200 statute miles from Seattle. The head of navigation on Knik Arm is 1,682 statute miles from Seattle by Juan de Fuca Strait and outside.

PHYSIOGRAPHY.

Kenai Peninsula includes two very different physiographic divisions: (1) The Kenai Mountains on the eastern side and (2) the

[1] Measurement from Map of Alaska, published by U. S. Geological Survey in 1915.

[2] Table of Distances in Nautical and Statute Miles via the Shortest Navigable Routes, Bureau of Navigation, Hydrographic Office, Navy Dept., No. 117.

Kenai lowland or plain on the western or Cook Inlet side. These divisions are separated roughly by a straight line from the head of Kachemak Bay to Burnt Island on Chickaloon Bay.

The Kenai Mountains comprise about 6,450 square miles of irregularly distributed peaks forming a rugged range about 150 miles long from Turnagain Arm to Port Chatham, and about 80 miles across in the widest place. (Pl. I.) The general range in altitude is from about 3,000 to 5,000 feet above sea level, with a maximum (in the area surveyed) of about 6,400 feet.[1]

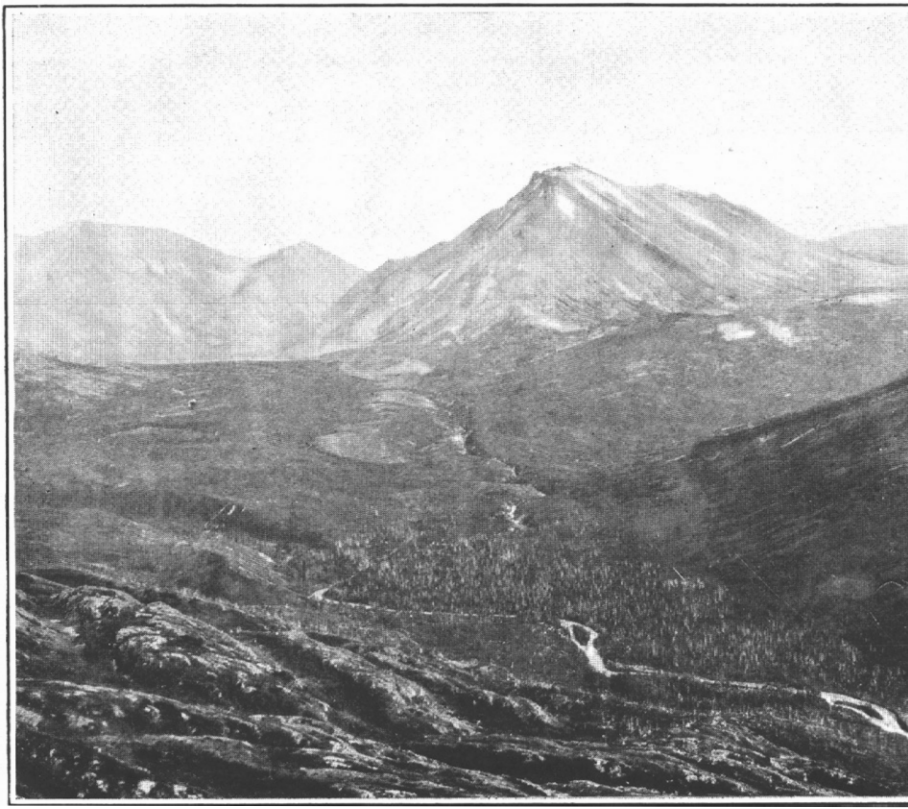
There are many glaciers in that part of the range south of Resurrection River and east of the Alaska Northern Railway. The heart of the area between Resurrection River and Port Dick constitutes a vast ice field from which many ice lobes come down to the sea on the east side and down to the bench lands on the west.

The Kenai lowland between Turnagain Arm and Kachemak Bay covers an area of something like 2,750 square miles, exclusive of the areas of the lakes. (Pl. II, fig. 1.) The length of this area from Bluff Point to Point Possession is 105 miles, while the east-west width at East Foreland is 46 miles. From Kenai Mountains this area appears as a vast lowland plain, composed of flats, low ridges, and hillocks, and muskeg, dotted with small lakes. The greater part of this plain has an elevation between 50 and 200 feet above sea level, although there is a large area of table lands, known as the Caribou Hills, between Kachemak Bay and Tustumena Lake, which properly belongs with the lowland division, where the elevation rises to more than 2,000 feet. Between Tustumena Lake and Funny River there is a long steplike rise through a series of benches to the steep-sloped mountains at an elevation of about 3,000 feet. Similar steplike rises to the mountain slopes are seen elsewhere.

Most of the shore lying along Cook Inlet is precipitous, consisting of bluffs that usually rise 40 to 300 feet above the gravel beach. (Pl. II, fig. 2.) But there are many places, especially north of Kenai, where the benches along the beach are low, not more than 10 to 20 feet above high tide. On the other hand, there are in places along the north shore of Kachemak Bay cliffs that are over 400 feet high. One of the principal low benches or flats fronting on the water is that at Homer Spit.

The shore line is one of long, sweeping curves with few conspicuous embayments or points. It is, in this respect, unlike the shore line in the southern part and eastern side of the inlet, which is very rugged, and characterized by numerous bays or fiords extending deep into the mountains.

[1] Geology and Mineral Resources of Kenai Peninsula, Alaska, Bul. U. S. Geol. Survey No. 587, p. 22.



BENJAMIN CREEK BASIN IN KENAI MOUNTAINS NEAR HEAD OF SKILAK

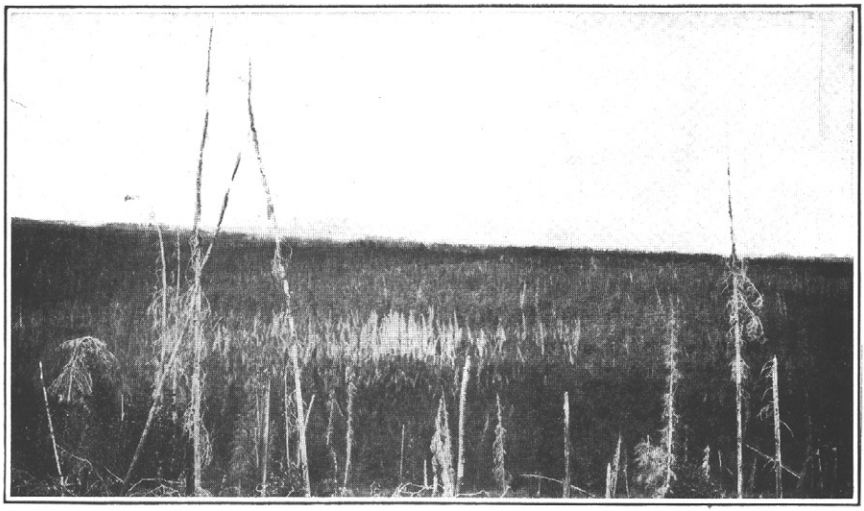


FIG. 1.—VIEW OF THE KENAI LOWLAND FROM THE KENAI MOUNTAINS.

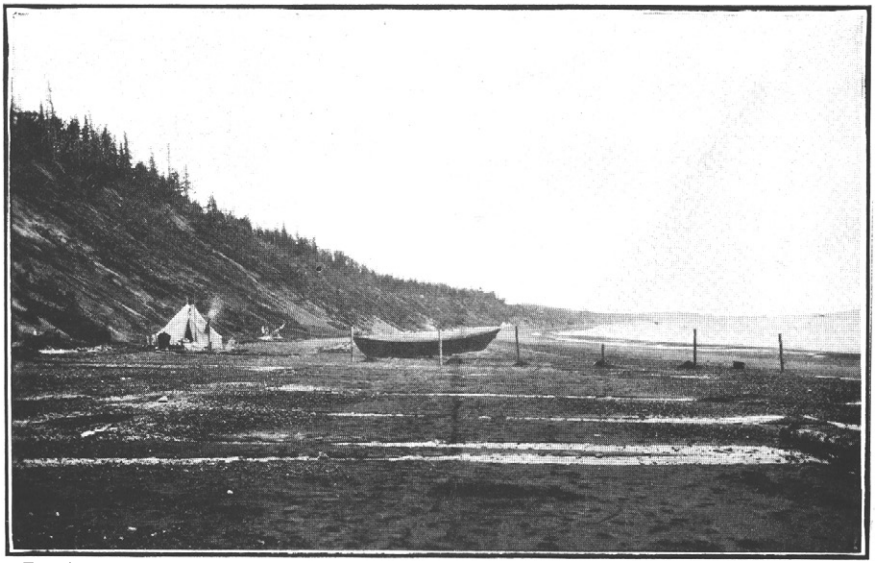


FIG. 2.—CHARACTERISTIC BLUFFS OF BENCH LANDS FRONTING ON COOK INLET. (CAMP NEAR EAST FORELAND.)

In a general way this lowland area consists of a series of broad ridges paralleling the shores of Cook Inlet, with intervening lower country, which, in the western half, includes much muskeg. There are many broad areas of hillocky country over the inner side of the plain, comprising irregularly arranged hillocks, ridges, and flattish shoulders, which give the surface a choppy character. There are occasional muskeg areas in the low places throughout the Kenai lowland, but the larger bodies of this are near the coast. While there are numerous flat benches, the greater part of the uplands (land other than muskeg and stream bottoms) throughout the plain is undulating or gently rolling to hillocky or choppy. Probably 80 to 90 per cent of the land has surface features suitable for cultivation, the remainder consisting of steep slopes between benches and along streams and the very hillocky country such as that near the forks of Chickaloon River.

The Kenai lowland or plain physiographically belongs with the other areas of "bench lands" bordering on Cook Inlet and extending up the valleys of the Susitna and Matanuska Rivers, and forming the Cook Inlet-Susitna Plain. It is similar in origin, also, to the bench lands elsewhere through the region, consisting of glacial outwash material left in the form of flat benches, hillocks, and ridges.

GEOLOGY.

The general features of the geology of Kenai Peninsula are described in a publication by the United States Geological Survey,[1] from which the following paragraphs are quoted:

> The mountainous and the lowland districts of Kenai Peninsula are geologically unlike. The mountains are composed of thoroughly indurated, slightly metamorphosed, and highly folded rocks of Mesozoic or earlier age which, though chiefly of sedimentary origin, include some intrusive masses. The lowlands are composed of slightly indurated and gently folded Tertiary beds. Quaternary deposits occur in both parts of the peninsula, but are much more widespread in the lowlands. * * *
>
> The most highly metamorphosed rocks on Kenai Peninsula are some schists that were observed on Seldovia Bay and Port Graham, including quartzitic sericite schists, quartzite, crystalline limestone, and greenish schists, of probably volcanic origin. * * *
>
> Slates and graywackes compose the greater part of the Kenai Mountains, the only other known rocks they contain being intrusive masses, which are most abundant on the southern and eastern coasts, the greenstones near Resurrection Bay, the volcanic beds interstratified with the slate and graywacke in the western part of the peninsula, and the Mesozoic and other sediments that compose the foothills along the southern shore of Kachemak Bay. * * *

[1] Martin, G. C., Johnson, B. L., and Grant, U. S., Geology and Mineral Resources of the Kenai Peninsula, Alaska, Bul. No. 587, U. S. Geological Survey, pp. 32–37.

Intrusive rocks are abundant in various parts of Kenai Peninsula. They are most numerous in the slates and graywackes, but a few were observed in the Triassic and Jurassic rocks. There are none in the Tertiary beds.

The most extensive of the intrusive rocks are the granitic masses, which are greatest and most abundant in the slates on the southern and eastern coasts. The largest masses occur in the vicinity of Aialik Bay and Pye Islands. An unmapped area of granite occurs at the headwaters of Benjamin Creek, near Skilak Lake.

Small acidic dikes are numerous in all the slaty rocks along the southern shore of the peninsula. They also occur in the slate and graywacke between Kenai Lake and Turnagain Arm and in the Crow Creek district. Small dikes of several kinds cut the slates and the Mesozoic rocks on the south shore of Kachemak Bay.

Masses of peridotite intrude the slate and graywacke at Red Mountain, southeast of Seldovia, and on the north shore of Port Chatham, and diabase and gabbro occur near Point Bede and Grewingk Glacier.

The only Tertiary beds of Kenai Peninsula are those of the Kenai formation, which is areally restricted to the Kenai lowland and to the southern shore of Kachemak Bay. This formation is about 2,000 feet thick, is composed of slightly consolidated sands and clays with many lignite beds, and is apparently wholly of nonmarine origin. Its fossil plants fix its age as Eocene.

The Quaternary deposits of Kenai Peninsula consist of extensive beds of glacial and terrace gravels, which cover practically all the Kenai lowland; of local deposits of high gravels, occurring in the Kenai Mountains; and of the recent alluvial and shore deposits, which are best developed as flood plains on the glacial streams and as deltas in the lake and tidal waters.

The distribution and character of the older gravels show that they were connected in origin with the glaciers that once occupied the region. At the time of maximum glaciation the Kenai Mountains were the site of an extensive system of alpine glaciers. They were largely coalescent and covered most of the mountain area except the higher peaks and ridges, but apparently did not submerge and override the entire mountain mass. The important fact to be noted is that these glaciers behaved as individual alpine glaciers and not as a continental ice mass. Throughout their entire existence their flow was directed by the valleys in which they originated and their erosive effects continued to consist very largely of bergschrund attack combined with accentuated deepening of the main glacial channels. They etched rather than polished the preglacial land. Until the glaciers began to melt away the Kenai Mountains were the site of glacial erosion and not of glacial deposition. During the same period the Cook Inlet basin was occupied by a great valley glacier, fluvial in form, provincial in magnitude. It received tributaries not only from the Kenai Mountains, but from all the mountain masses that now encircle the Cook Inlet-Susitna basin. The main lower stem of this glacial stream lay across the Kenai lowland. It was doubtless a sluggish and heavily waste-laden mass, and deposited a tremendous volume of sediment, so that the Kenai lowland presented a marked contrast to the Kenai Mountains. The lowland was a district of glacial deposition; the mountains a district of glacial erosion. The Quaternary deposits of the Kenai lowland consist of a thick sheet of till interstratified with local beds of water-laid sands and gravels and overlain by a cover of stratified and terraced sands and gravels. The Quaternary deposits of the Kenai Mountains are comparatively insignificant in volume and are closely related in distribution and composition to the local land form and rock character.

The Kenai Peninsula consists of two very distinct structural provinces, the Kenai Mountains and the Kenai lowland. The Kenai Mountains are structurally complex, the rocks being everywhere closely folded and the argillaceous beds having a slaty cleavage. The Kenai lowland is structurally simple, its characteristic structural features being broad, gentle folds. The structural relations of the rocks along the boundary between these two provinces are not known, for the rocks are not there exposed.

The structure shows no distinct regional variation in character within the Kenai Mountains, but apparently varies in complexity with the age of the rocks. There is a progressive change from schists that are both highly metamorphosed and closely and intricately flexed, through slaty rocks that show various degrees of metamorphism and of complex folding, Triassic rocks that are sharply folded but not metamorphosed, and Jurassic tuffs that are involved only in monoclinal dips and normal faults, to Tertiary outliers which, though faulted, are nearly horizontal and but poorly indurated.

REGIONAL DRAINAGE.

The greater part of Kenai Peninsula is drained by streams entering Cook Inlet, the largest of which are Kenai, Kasilof, Chickaloon, Ninilchik, and Swanson Rivers and Resurrection, Sixmile, and Fox Creeks. The principal stream entering the Pacific, aside from those rising directly from glaciers close to shore, is Resurrection River, emptying at the head of Resurrection Bay. The Geological Survey estimates that more than half of the area of the peninsula drains into Cook Inlet and its arms.

Kenai River heads less than 10 miles from Resurrection Bay, flowing through Kenai Lake at an altitude of 470 feet and then through Skilak Lake, 15 miles below, at an altitude of 300 feet. The upper part of Skilak Lake lies in the mountains, with the lower part extending out into the Kenai lowland. From the lower end of this lake Kenai River flows westerly, across the lowlands to Cook Inlet, receiving a number of important tributaries, the chief of which are Killey, Funny, and Moose Rivers. The current is swift down to tidewater, about 10 miles above its mouth. There are rocky rapids between Kenai and Skilak Lakes and below Skilak Lake. Only small boats in the hands of experienced rivermen can go down this stream safely; up stream they have to be towed. Kasilof River, the second stream of the peninsula in size, can be ascended to Tustumena Lake by poling boats, tidewater extending up nearly a third of the distance.

The only considerable part of the lowland country in which drainage is poorly established is the muskeg, and this lacks drainage because of inadequate outlets for the water that accumulates in low flats occupied by these peat bogs. By far the greater part of the benches, ridges, and hill land is underlain by gravelly material that affords good to excessive underdrainage. There are occasional slopes

that are kept wet by the seepage, and also depressions that remain damp through the summer, both because the underdrainage is not perfect and because there is some seepage from adjacent slopes. There are boggy places in the mountain and stream valleys, and occasional strips along lower slopes that are permanently wet and covered with peaty or mucky accumulations. In late summer the higher mountain slopes are mostly bare with a patch of snow here and there in shaded places and in ravines. The higher, interior portion of the Kenai Mountains south of Resurrection River is covered by a large snowfield from which valley glaciers flow in all directions.[1]

In summer the streams connected with the glaciers carry a large volume of water, at times inundating the "glacier flats" or deltas, such as those below Spencer Glacier and along Resurrection River. The bottoms of streams not receiving water from the glaciers are not frequently overflowed, at least no evidence of frequent overflows were noticed. The rains characteristically are not torrential, and the soils take up much of the rainfall, which factors contribute toward the prevention of stream overflows. Most of the streams of the Kenai lowland carry clear or slightly dark colored water, the latter coming from mucky flats and peat bogs (Muskeg). Kenai River carries water that is slightly grayish or milky, owing to suspended glacial material. Streams like Russian and Funny Rivers that receive the bulk of their water from lakes in the mountains near glaciers carry clear water. Resurrection River, on the other hand, with many of its tributaries rising directly from glaciers, carries in summer the typical milky water of glacier streams. In places the stream bottoms are wet through summer, but this is apparently due mainly to the low situation and absence of outlets to the stream channels.

FLORA.

The vegetation of Kenai Peninsula varies with the soil, drainage, elevation, and locality. On Turnagain Arm and in the lower valleys of the mountainous area, as on the flats along Resurrection River above Seward, hemlock is common, but on the Kenai lowland this tree is rarely or never seen. The principal trees of the lowland division are white and black spruce, birch, aspen, and cottonwood, and these trees also predominate over much of the mountain slopes.

Osgood[2] has this to say of the flora of the Cook Inlet region:

> The flora of the Cook Inlet region is quite different from that of the coast farther south, although many species are common to both regions. The difference is largely in the reduction of the number of coniferous trees in the Cook

[1] Geology and Mineral Resources of Kenai Peninsula, Alaska, Bul. U. S. Geol. Survey No. 587, pp. 25–26.

[2] Osgood, Wilford H., Natural History of the Cook Inlet Region, Alaska, North American Fauna, Bureau of Biological Survey, U. S. Dept. of Agriculture, No. 21, p. 53.

Inlet region and the corresponding increase in deciduous trees; but other features somewhat transitional between the heavy saturated forest of the southern coast and the treeless tundra of the north are numerous. The flora of the mountainous district about Turnagain Arm is, of course, different from that of the coastal plains of other parts of the inlet.

The low country near Hope consists of a grassy tide flat, about 50 acres in extent, and a few miles of forest and occasional small swamps along the lower part of Resurrection Creek. Balsam poplars, paper birches, alders, and willows abound near the streams, and spruces (*Picea canadensis* and *P. sitchensis*) and hemlocks (*Tsuga mertensiana*) are common on the slopes and slightly elevated flats. A third species of spruce (*Picea mariana*) is found in the small peat bogs, where smaller Hudsonian plants, such as Labrador tea (*Ledum*), crowberry (*Empetrum*), and dwarf birch (*Betula glandulosa*), are in profusion. The hemlock is much the most abundant of the large trees, but it is exceeded in individual size by the spruces. The conifers ascend the mountain slopes to about 2,000 feet, but above that point rapidly disappear. Beyond this elevation are alder thickets, small patches of dwarf willows and birches, and vast stretches of waving grass from 1 to 3 feet high. Still higher the slopes and rounded backs of the ridges are cushioned with a mass of heather and heatherlike shrubs, chiefly *Empetrum nigrum*. This extends up to an approximate altitude of 5,000 feet, above which there is very little or no plant growth. The whole country is characterized by the abundance of high grass; otherwise it is a typical Hudsonian-Alpine region.

The timber line is at an elevation of about 2,000 feet above sea level, so that a large part of the peninsula—the high mountain country—is void of timber. Other treeless areas represent bodies of Muskeg and areas on which the timber has been destroyed by forest fires.

There is a vegetative zone above timber line that extends to about 4,000 feet, but trees, with the exception of an occasional scrub hemlock, are not found in it. In this zone the plants become smaller and more scattered with increase in elevation. Alder is very common in many places up to about 3,000 feet, the bushes growing in such dense thickets and in such a sprawling manner that travel through them is difficult. This alder zone is interspersed with glades—open places of native redtop (*Calamagrosti* sp.), fireweed (*Chamænerion angustifolium*),[1] and other plants. Above this zone the redtop gives way to bunch grass or to a heather growth with occasional dense clumps of very stunted hemlock. Mountain heather is the typical vegetation above the alder-redtop zone. This is composed of blueberry, dwarf birch, Hudson Bay tea, or Labrador tea (*Ledum decumbens* and *Ledum groenlandicum*), moss berry, or crowberry (*Empetrum nigrum*), ptarmigan berry (*Arctus alpine*), sphagnum, and reindeer moss, and other low-growing plants. In the moister situations scrub willow is abundant. Mountain ash is

[1] Most of the plants whose botanical names are given in this report were identified from specimens collected by the writer by Mr. Frederick V. Colville, botanist, in charge, Economic and Systematic Botany, Bureau of Plant Industry, U. S. Dept. of Agriculture.

occasionally found above and below timber line. Wild flowers, such as the violet, bluebell, golden rod, and aster, blossom abundantly on the mountains above timber. Blueberry and reindeer moss an inch or so high are frequently found scatteringly high up the rocky slopes, where the soil is very thin and scarce, and where patches of snow linger throughout summer except in the sunniest situations.

Over the Kenai lowland there are two principal types of vegetation: (1) Timber on the well-drained benches, ridges, and hillocks, and (2) heather on the Muskeg. The trees are white spruce, black spruce, birch, cottonwood, and aspen. The principal undergrowth associated with these trees consists of alder, willow, buckbrush (*Menziesia ferruginea*), devil's club, currant, high-bush cranberry (*Viburnum pauciflorum*), and wild rose. In the open places in the woods redtop is usually found in luxuriant growth. (Pl. III.) Some of the plants that grow in both the woods and open places, in fact, nearly everywhere except on Muskeg, are bunchberry or Indian paint berry (*Cornus canadensis*), low-bush cranberry (*Vaccinium vitisidæa*), sphagnum moss, joint grass, or horsetail (*Equisetum sylvaticum* and *E. palustre*), wild rose, and moss berry or crowberry (*Empetrum nigrum*). Joint grass and redtop also grow scatteringly on Muskeg. Redtop is usually not abundant in the heavy burns, the principal small plants here being Hudson Bay tea, bunch grass, low-bush cranberry, moss, joint grass, wild rose, lupin (*Lupinus nootkatensis unalaschensis*), and fireweed (*Chamænerion angustifolium*). Hudson Bay tea is a plant that grows at all altitudes from near sea level to above timber line throughout most of Alaska, but it is most plentiful in Muskeg, muck bogs, and open places where there is not much grass.

On the open slopes and table-lands bordering Kachemak Bay on the north side there are large natural meadows of redtop in extraordinarily rank growth, much of it being 6 to 9 feet high and sufficiently thick to cut 4 or 5 tons of hay per acre. (Pl. IV.) Higher up it is shorter and more mixed with fireweed, lupin, and bunch grass. Some bluegrass (*Poa pratensis*) was also found here. In other places—at Kenai and Ninilchik and elsewhere on the lowlands—several other grasses were found, such as *Festuca rubra lanuginosa*, *F. rubra kitaibeliana*, *F. altaica*, *Hordeum montanense* ("wild timothy" or "wild barley"), *Poa hispidula*, *P. palustris*, *P. acutiglumis*, and "mountain timothy."

The typical heather growth of the open Muskeg includes sphagnum moss, blueberry, Hudson Bay tea (*Ledum* sp.), moss berry (*Empetrum nigrum*), wild sage, and dwarf birch (*Betula* sp.) as the principal plants. Among other common plants found here are small black spruce, *Myrica gale*, squaw berry (*Rubus chamæmorus*), joint grass (*Equisetum* sp.), and slough grass (*Carex* sp).

The less boggy or shallow phase of Muskeg supports a dense growth of small black spruce, much sphagnum moss, dwarf birch, squaw berry, and some willow and alder. The mud flats are covered with an abundant growth of goose tongue (*Plantago maritima*), marsh marigold (*Parnassia palustris*) and much beach rye (*Elymus mollis*), especially near the edge of the water. Slough grass is also abundant in wet places farther back from salt water. On the gravelly bench slopes near salt water and on the beaches beach rye, large wild pea (*Lathyrus maritimus*) and small wild pea are plentiful.

White spruce is the most abundant tree in the forests of the Kenai Peninsula, especially on the lowlands, black spruce being second. The two trees generally are not found in mixed growth, occurring, as a rule, under dissimilar conditions of soil and drainage. The former tree prefers the deeper, well-drained loam, although some of the largest specimens are those growing in the moist stream bottoms where gravelly and sandy soil is plentiful. It does not grow on Muskeg and is far less abundant on those flats where there is only a thin mantle of soil over gravel and sand. It does not thrive so well in those places that have favored the accumulation of peat and deep, partially decomposed moss, especially where the underlying material is frozen through summer at shallow depths, as is true in portions of the Muskeg. Black spruce is the characteristic tree growth on the Muskeg where there are any trees at all, on the deep, moss-covered areas of shallow Muskeg, and on the flats of thin soil—those areas known as "G pole flats." (Pl. V.)

Birch is second to spruce in importance throughout the peninsula from near sea level to timber line. It occurs chiefly in mixed growth with white spruce, to some extent with black spruce, and occasionally in unmixed groves. The best birch, like the best spruce, is found on the best soil—the deep loam—and at elevations ranging up to something like 1,200 to 1,400 feet. Some of the largest trees grow in the moist stream bottoms, even where there is considerable muck at the surface, just as is the case with spruce. In other words, the best birch in this region is found in mixed growth with the best spruce. As a general thing these trees become smaller as the soil becomes thinner, and they are more and more stunted with increase in elevation above the 1,200 to 1,400 foot line. There are not so many pure stands of birch in this region as in the interior of Alaska, in the Fairbanks section, for instance. More pure stands of birch were seen (in 1914) on the west side of Cook Inlet and up the Susitna Valley than on the east side of the inlet.

White spruce frequently attains a diameter[1] of 20 to 24 inches and a height of 80 to 100 feet or more, with occasional veterans measur-

[1] Tree measurements through this report are diameter breast high.

ing up to about 26 inches. (Pl. VI.) By far the greater part of the spruce consists of small poles (4 to 8 inches), lodge poles (8 to 12 inches), and standards (12 to 24 inches). On the shallower bench land the trees seldom exceed 10 inches. Black spruce is found mainly as saplings 4 inches or less in diameter, although the trees frequently attain a size of 4 to 8 inches on the shallow loam, as in the hillocky country north of the mouth of Killey River, and on mossy flats underlain by well-drained soil material at depths of 2 feet or less, as in the very dense forest skirting Chickaloon River on the west side above the tidal flats. A few black spruce trees range upward of 10 or 12 inches. Some of these larger specimens are difficult to distinguish from white spruce. On Muskeg the black spruce is very small, seldom larger than saplings, although they may be a hundred years old.

Some birch trees are found that measure 20 inches in diameter, and many of them are 16 to 18 inches across the stump. The majority are lodge-pole and small-pole size.

Aspen ("poplar" or "quaking asp") is the third tree of importance. Most of it occurs as saplings on the burned-over areas, frequently in pure stands. In some of these burns, such as those between Tustumena and Skilak Lakes, there are large groves of aspen saplings that are uninterrupted by or contain only a scattering of other trees. Birch saplings are common over many of the burned tracts. Aspen attains a diameter of 16 inches or more in places, but large trees are relatively scarce. The larger trees are found over the well-drained loam soil of the bench lands in mixed growth with white spruce or with white spruce and birch.

Cottonwood ("poplar"), the largest tree of the Kenai lowland, attains a maximum diameter of about 3 feet. (Pl. VII, fig. 1.) The characteristic habitat of this tree on Kenai Peninsula is the gravelly, sandy, and silty soils of the stream bottoms. It frequently occurs, however, on well-drained highland (bench land and mountain slopes), along with spruce and birch.

Hemlock, the largest tree found anywhere on Kenai Peninsula, is abundant in places on Turnagain Arm and in the valleys on the western side of the peninsula. It is most abundant on the glacier flats, such as those along lower Glacier, Resurrection, and Salmon Creeks. Some of the trees are 4 feet or more across the stump.

FOREST FIRES.

Large areas of timber have been completely destroyed by forest fires. On all the trips made on Kenai Peninsula we rarely traveled a distance of more than 2 miles without entering a burned area. We did see from elevations of commanding view some large forests where no evidence of burns could be made out with field glasses, such, for

NATIVE REDTOP IN AN OPENING IN THE BIRCH-SPRUCE FOREST OF KENA

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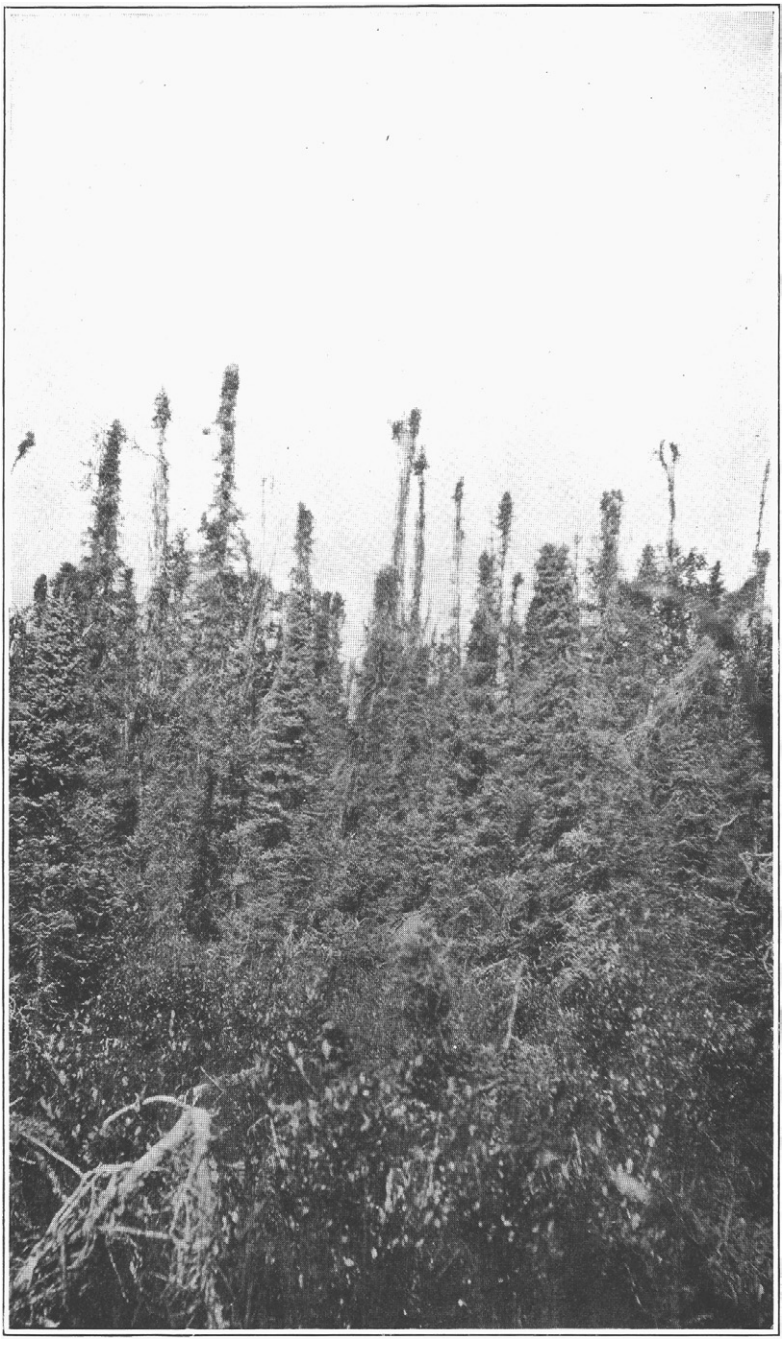
NATIVE REDTOP 8 FEET HIGH, NORTH SIDE OF KACHEMAK BAY.



BLACK SPRUCE FOREST ON KENAI PENINSULA.

THE BEST TYPE OF WHITE SPRUCE ON THE KENAI PENINSULA.

This forest is on deep Knik loam. The largest of these trees have a diameter of 24 inches.

example, as the extensive timbered tract about the headwaters of Deep Creek seen from Cape Ninilchik.

At Kenai we were told that a big fire went over the country from the head of Tustumena Lake to the mountains in 1890. This same area we were told had been previously burned, probably by the Russians, but there had been substantial reproduction at the time of the big fire of 1890. There was another big forest fire about the lower end of Tustumena Lake in 1911. Since these fires, aspen and birch have taken possession of probably more than 100 square miles of burned-over land between Tustumena Lake and Kenai River and Skilak Lake. The rapidity with which aspen and birch saplings reproduce over such devastated areas has had much to do with the exceptional abundance of moose in this section. Such groves make the very best moose pastures.

In most of these burns, also, spruce reproduction is taking place. If other fires should not occur, the spruce probably would largely crowd out the aspen eventually to form typical spruce or birch-spruce forests.

These fires have been very destructive to timber. In most cases nearly every tree of any size was killed, and 90 per cent or more of them fell, upturning their roots. The trees have very shallow root systems, and when the leaf mold and moss burn, portions of the tree roots are consumed, so that many of the trees either fall at the time or are blown down subsequently. (Pl. VII, fig. 2.) The trees have simply fallen one upon another, forming a tangle the crossing of which presents tiresome difficulties to the traveler, especially in the stage before much decay has taken place. Elsewhere the fallen trees have been largely destroyed by fire—probably a second fire—leaving the ground open and easy to get over.

Some burning takes place on Kenai Peninsula nearly every year. Recently, with the widespread activities accompanying railroad construction and mining, it is generally possible in dry seasons to see from an elevated point many fires burning through the Cook Inlet lowlands and adjacent mountain slopes. There are more fires, of course, in those sections where there are more clearing, lumbering, and constructional activities, as in the country between Seward and Turnagain Arm, along Knik Arm and in the Susitna and Matanuska Valleys, where the railroad is building; but the increasing number of homesteaders on the Kenai lowland may be expected to increase the danger of the fires here. At this time it is still possible for homesteaders to get native lumber for the construction of barns, dwellings, and bridges at comparatively short distances, and if fires could be controlled there would be enough timber for a largely increased population for many years to come. But if the increasing number of fires are to burn undisturbed, there will certainly be an acute want

in the future, especially among farmers, for the very timber that is now being ruthlessly destroyed at a rate which is alarming. Some means of effectually preventing or combating forest fires in those parts of Alaska where settlement is taking place or is likely to take place should be taken immediately, or else the timber so necessary for development of the country will surely and speedily be thrown away. And it should be remembered that the valuable trees grow slowly here.

Most of the forest fires are started by homesteaders, timbermen, railroad constructors, prospectors, and hunters, generally through carelessness and without thought of the seriousness of the destruction done. It is unfortunate that many, unconsciously perhaps, maintain a kind of flippant attitude toward the value of the native timber, even along the Government railroad, where one sees large quantities of crossties, piling, and boards from the Cook Inlet forests. All the crossties and piling so far used on the new railroad, and all the ties, piling, and bridge timbers used on the 70.8 miles of the Alaska Northern Railway, consist of native timber, most of which was cut from the forests of Kenai Peninsula and the Cook Inlet lowlands.[1] (Pl. VIII, fig. 1.)

The fact that there are considerable tracts of small timber, black spruce forests of saplings and small poles, locally styled "G pole flats," and also numerous scattered groves of small aspen, birch, and white spruce, apparently has had much to do with the frequent lack of serious appreciation of the regional timber as a whole; in other words, the presence of much timber valuable only for firewood has, in a manner, placed a stigma upon the entire forest of the region in which there are large quantities of valuable structural timber. Such an attitude necessarily is seriously inimical to the welfare of the country's timber resources. It is a state of mind based upon misconception and thoughtlessness. It should be immediately remedied; public-spirited citizens should endeavor to bring the mind of the public to see the necessity of conserving the timber that will be needed for dwellings, farm buildings, bridges, telephone poles, etc. Homesteaders should be brought to see the wastefulness of burning over more ground than is actually needed for cultivation in their clearing operations. At present the area burned is too often limited to the area favorable to the ravages of an unchecked forest fire. The same is true of many of the fires started in other ways.

A number of fires in that portion of the Chugach National Forest between Turnagain and Knik Arms were put out in the summer of 1916 by the single forest ranger stationed on Cook Inlet. The town

[1] See Reports of the Alaskan Engineering Commission, Doc. No. 610, pt. 2, House of Representatives, 64th Cong., 1st sess., pp. 72–73.

of Anchorage was endangered in the spring of that year by a forest fire that reached its outskirts before it could be controlled.

A public opinion aroused to the point of cooperation with authoritative agencies charged with control of forest fires and the regulation of lumbering operations along lines conducive to the most economical use of the forests probably is the best means of preventing waste. The putting into force of such agencies should not be delayed, and the personnel should include sufficient numbers to carry out an effective supervision.

Notwithstanding the fact that timber on hundreds of square miles of Kenai Peninsula has been burned, there is still a large total area of forested land on which there is much merchantable timber. The areas are scattered—separated by burned-over areas, by Muskeg areas, and by bare mountainous country and glaciers. At the present time the more accessible portions of the forests of both the lowland and mountainous divisions of the peninsula are being drawn upon for crossties and piling to be used on the Government railroad, for fish-trap building, and for lumber for the construction of bridges and buildings for the villages and ranches.

SETTLEMENT AND GENERAL DEVELOPMENT.

The Russians were the first whites to settle in the Cook Inlet region. They established missions and fur-trading posts at several places on Cook Inlet and carried on considerable trade with the natives. A shipyard was established on Resurrection Bay, and the first ship built in Alaska was launched here in 1795. The first agricultural colony was established on the east shore of Cook Inlet in 1793.[1] Descendants of these and other colonists are still living at Ninilchik, Kenai, Seldovia, and other places on Kenai Peninsula. The Russian language, which is spoken by whites and natives at these places, and the Russian churches are the present chief evidences of the Russian occupation.

The early colonists are supposed to have landed at or near Ninilchik, having come from Kodiak Island. The native cattle now at this village are said to be descendants of cattle brought from Russia about the time this settlement was effected. There is no evidence of any important areas of land having been cleared and cultivated by the Russians. It is improbable that farming at any time was much more extensive than that now carried on about the villages on Cook Inlet.

Brooks[2] has this to say about early surveys of the Kenai Peninsula:

> To Capt. James Cook, who made a voyage to Alaska in 1778, must be credited the first survey of the shore line of any part of Kenai Peninsula, yet undoubtedly

[1] Brooks, Alfred H., in Bul. U. S. Geol. Survey No. 587, p. 14.
[2] Idem, p. 13.

the peninsula was known to the roving Russian fur trader before Cook's visit. When Cook made his voyage the Russians already had a permanent trading post on Kodiak Island and were invading the adjacent waters in their search for the valuable sea otter. To Cook's officers, Portlock and Dixon, but more especially to Vancouver, fell the task of surveying the shore line in greater detail. The work of these earlier navigators during the succeeding half century was amplified by surveys of various parts of the coast line. The surveys made by Russian naval officers and by employees of the Russian-American Fur Trading Co. are especially noteworthy. That a fairly complete knowledge of the geography of the region was thus gained is made evident by the charts of the peninsula and the accompanying text, in Tebenkof's Atlas of Russian America, published in 1852.

Following the purchase of Alaska by the United States in 1867, Americans entered the region and took up the lines of industry followed by the Russians, trading with the natives for furs. The Alaska Commercial Co., an American company, which succeeded the Russian Fur Trading Co., had trading stations at Knik, Tyonek, Susitna, Talkeetna, Beluga, Hope, and Sunrise. For many years after the American succession industrial conditions changed but little on the peninsula.

Some placer gold was taken out, and coal mining was attempted by the Russians on Kenai Peninsula. The first gold mined in Alaska was that taken out in the Kenai River in 1850 by Doroshin.[1] In 1854 the first Alaskan coal was mined at Port Graham. Here Russian steamers were supplied with coal. An attempt was made in 1889 to develop the lignitic coal at Kachemak Bay for export to the Pacific coast of the United States, but the venture was not successful.[2]

Gold was found at Anchor Point in beach placers about 1890, and the placers of Bear and Palmer Creeks were found in 1894. In discussing this discovery Brooks[3] states:

> This led in the next two years to an influx of prospectors into a region which up to that time had been known only to the fur trader. These prospectors swarmed over the peninsula and began mining in many places. In 1896 a gold-bearing quartz lode was found near Moose Pass, but this excited little interest.
>
> Kenai Peninsula contains auriferous lode-bearing areas of some promise, though deep mining has so far been done on only a small scale. Auriferous gravels are widely distributed in the northeastern part of the peninsula and have been mined in a small way for nearly 20 years. The future of placer mining on the peninsula depends on the exploitation of many large bodies of gravel carrying values too low to permit development by the simple methods thus far chiefly used.

An interesting gold-seeking expedition, the Kings County expedition, sailed from New York in the spring of 1898, the writer was

[1] Doroshin, Peter, Einige Beobachtungen und Bemerkungen über die Goldvorkommen in die Besitzungen der Russisch-Amerikanischen Compagnie: Archiv. wiss, kunde Russland, vol. 25, pp. 229–237, 1866.

[2] Brooks, Alfred H., in Bul. U. S. Geol. Survey No. 587, p. 15.

[3] Loc. cit.

told, outfitted for mining on Turnagain Arm. After a long schooner trip by the Horn and unexpected delays, the ship was towed into Kachemak Bay the latter part of the year. The expedition left Kachemak Bay that winter and attempted to cross the peninsula to Turnagain Arm through the trailless country by Tustumena and Skilak Lakes. With burdensome supplies and without knowledge or adequate means of traveling here in winter, the party succeeded in reaching the shores of Skilak Lake after severe hardships, where cabins were built at the mouth of Kings County Creek. (Pl. VIII, fig. 2.) Discouraged by the severe hardships of the trip and by sickness, and disorganized by dissensions among themselves, the originators of this ill-fated venture stopped at this point, and most of the party built boats of whipsawed lumber and descended Kenai River. Only two or three of the entire party remain in the Cook Inlet country, it is said. Kings County Creek entering Skilak Lake received its name from this luckless expedition.

At the present time placer mining is being carried on along a number of the creeks in the mountainous portion of the peninsula and in a small way on Kenai River. The most important operations are those on the creeks between Hope and Sunrise and Kenai Lake.

The principal gold-mining districts of the Cook Inlet country are the Willow Creek gold-lode ("quartz") district of the lower Susitna Valley and the Yentna River placer district. Placer operations are also being carried on elsewhere, as on Glacier Creek on the north side of Turnagain Arm.

Thick veins of lignitic coal outcrop in the bench escarpments in many places along Cook Inlet. (Pl. IX, fig. 1.) This is used by the inhabitants along the shore and by some of the boats plying these waters. This year about 2,000 tons were mined near Bluff Point on Kachemak Bay and shipped to Anchorage, Seward, and to the various canneries on the inlet. The vein here is 5 feet 8 inches thick, with 2 inches of clay 18 inches above the bottom of the vein. The price received for the product was $2.50 a ton at the mine.

While there are immense quantities of this coal, it may not be worked in the near future in an important way, after mining operations begin in the near-by high-grade coal field of Matanuska Valley, the edge of which was reached this year (1916) by the Government railroad.

POPULATION.

The development of gold mining in the Cook Inlet country caused a considerable increase in the population of Kenai Peninsula along Turnagain Arm particularly, and this was augmented with the beginning of construction on the Alaska Northern Railway at Seward in 1903. When construction on the road was suspended in 1906, in-

dustrial conditions were depressed and the increase in population ceased, the mining industries not having increased greatly as a result of the railroad work. With resumption of railroad construction in 1915 the population again began to increase at Seward and along the line of the road.

The present population of Seward is probably about 1,500. (Pl. IX, fig. 2.) A few hundred, chiefly laborers, are living along the line of the railway between Seward and Anchorage. The estimated population of the village of Kenai is 300; Ninilchik (Pl. X, fig. 1), 100; and Seldovia (Pl. X, fig. 2), 200, the majority of these being natives and descendants of early Russian settlers. There are perhaps 150 natives, homesteaders, miners, and prospectors living elsewhere between Turnagain Arm and Seward, mostly along the shore of Turnagain Arm, Cook Inlet, and Kachemak Bay. In summer several hundred laborers come in from San Francisco and elsewhere along the Pacific coast to work at the canneries. Most of these return home in the fall when the canneries close down.

Most of the population on Turnagain Arm live at Hope and Sunrise, which are the centers of the placer-mining industries in this part of the peninsula. The permanent population of this district is perhaps 200.

At the present time there are probably between 2,500 and 3,000 persons on Kenai Peninsula. This is a relatively large number for the area, since the total population of Alaska is probably something less than 100,000.[1]

Along upper Cook Inlet and in the contiguous valleys of the Susitna and Matanuska Rivers there is a considerably larger total population than on Kenai Peninsula. Anchorage alone has between 4,000 and 5,000. In the early part of 1914 the total population of the Cook Inlet region, including all of Kenai Peninsula, was about 2,500; by the end of 1916 it was probably close to 10,000.

The whites of the Kenai Peninsula are of various nationalities, including Americans, Swedes, Finns, Germans, and descendants of Russians. There are probably between 300 and 400 natives on the Kenai Peninsula and approximately 700 in the whole Cook Inlet region, including the peninsula.

THE NATIVES.

The natives, aside from the Russian descendants, are very largely pure-blooded Alaska Indians. They belong to the southwestern Alaska tribes, which are considered distinct and separate tribes

[1] The population of Alaska, according to the census of 1910, totaled 64,356, and of this number 25,331 were Indians. Since this time large numbers have come into the Cook Inlet and Tanana Valley region as a result of the construction of the Government railroad and the growth of the fisheries.

from the Eskimos inhabiting the coast country north of the Alaska Range, and from the Aleuts inhabiting the Aleutian Islands.

The chief occupation of the natives is fishing and hunting. They catch salmon with gill nets, drying the fish for food, both for themselves and their dogs. They also sell salmon to the canneries. They kill many moose for food and also some bear, sheep, and game birds. They do some trapping, but with the coming of the salmon canneries and the building of villages they do far less trapping than formerly, since it is possible for them generally to make what money they desire by working in the canneries and at other odd jobs and by fishing for the canneries. Some of them, chiefly those on the west side of Cook Inlet, make snowshoes for sale. Their efforts in agriculture have been of negligible importance; many of them have no gardens at all. They should be encouraged by the whites in gardening, in methods of sanitary living, and in the acquiring of habits of thrift. They are a peaceful people, and deserve the good will and assistance of their white neighbors.

The Indians live in houses built of spruce logs. These generally are of substantial construction, but in many instances are overcrowded and imperfectly ventilated. A few families live in isolated localities, but the greater number congregate in villages, as at Kenai and Seldovia. Tubercular diseases are said to have diminished the native population of the region considerably, at least in some localities. The writer was informed at the village of Kenai that there are not nearly so many natives there as there were 10 or 15 years ago, the population having been reduced by disease. It was stated that at the time of the war between the Tyoneks, natives of the western side of Cook Inlet, and the Kenai Indians, Kenai had several times its present population.

Our party encountered at Point Possession a distressing instance of the helplessness of the natives. Landing at this isolated point in July, we found every member of the two families of Indians living there, including about a dozen individuals, sick with measles and tuberculosis. They were sprawled upon the floors of their cabins coughing and moaning in a most pitiful manner. For several days they had had no food but salmon, and were too ill to send for help. Every member of one family, where there was a child 2 weeks old, was too feeble to go out of the cabin. The sanitary conditions indoors were very bad. Some food was left them, and a few days later, after getting word to Anchorage, a physician went to their assistance. The father of one family died a few days after we were there.

The children attend school very well, it is said, at villages such as Kenai, Ninilchik, and Seldovia. These villages also have Russian churches, where services are regularly attended by most of the natives.

The governor of Alaska says in his annual report to the Secretary of the Interior, 1915:

> The United States Bureau of Education continued to do what it could to alleviate the sufferings of the native population by doing work along medical lines. Approximately $30,000 was used for this purpose, and besides with this sum three small hospitals (Nushagak, Nulato, and Kotzebue) were maintained, at each of which a doctor and nurse were stationed. In addition the bureau maintained doctors at Nome, Russian Mission, Seward, Juneau, and Sitka. Besides the nurses at the hospitals, nurses were also stationed at Nome, St. Michael, Russian Mission, Koggiung, Hydaburg, and a traveling nurse for the southwestern district. Anyone at all familiar with the vast extent of the Territory will appreciate at a glance how entirely inadequate this medical force is and how utterly impossible it is to reach, with such limited funds at its command, but a very few of the 25,000 natives of Alaska. The appropriation of at least $125,000 annually is needed to establish a tubercular sanitarium and several hospitals at centers of native population, these institutions to be thoroughly equipped and situated at accessible places, together with the employment of a sufficiently large corps of physicians and nurses to make it possible to reach the greater part of the native population. A memorial to this effect was passed by the Territorial legislature, session of 1915, and it is imperative that Congress make ample provision for the medical relief of the natives of Alaska. The cause of the natives is not hopeless if provision for their relief can be made at once.

A hospital was opened in 1916 at Juneau that will accommodate 20 patients. An increased medical appropriation by Congress for 1917 will permit the building of another hospital on the Kuskokwim River.

SOCIAL CONDITIONS.

The larger towns of the Kenai Peninsula region, Seward and Anchorage, have good mail and cable service, and good hotels, schools, churches, and newspapers. There are many substantial and attractive spruce-log and weatherboard houses. The opportunities for social activities are about the same as in any town of equal size in the United States. There are moving-picture houses and social and commercial clubs. Much interest is taken in athletics, and there are abundant means of out-of-door recreation, such as hunting, fishing, boating, bathing, picture-taking, and berry-picking parties.

Some of the homesteaders live in isolated localities in comfortable spruce-log cabins. (Pl. XI, fig. 1.) Most of these get out to the villages occasionally. Some of the trappers and some of those raising foxes are even more isolated and come to the villages less frequently. Trappers often spend much of the winter in small log cabins far removed from settlements. Prospectors make long trips in summer, over difficult ground, sometimes with only blankets for shelter.

As settlement advances and roads, trails, and bridges are built, living under such conditions of isolation, of course, will be made

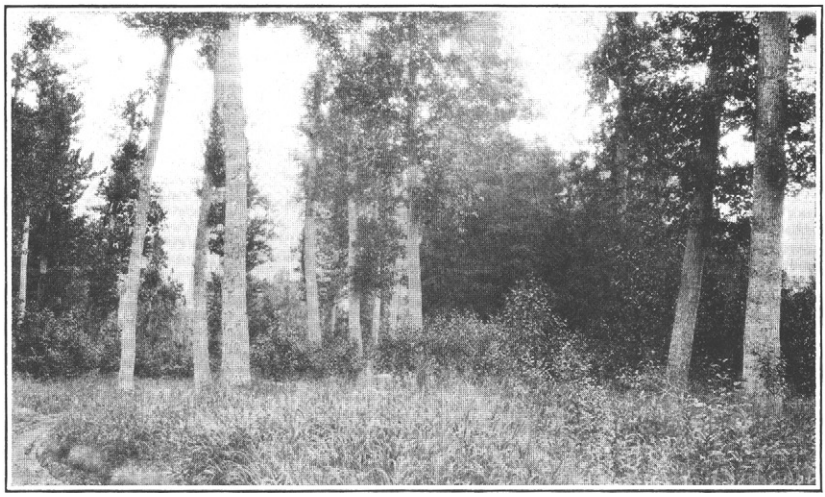


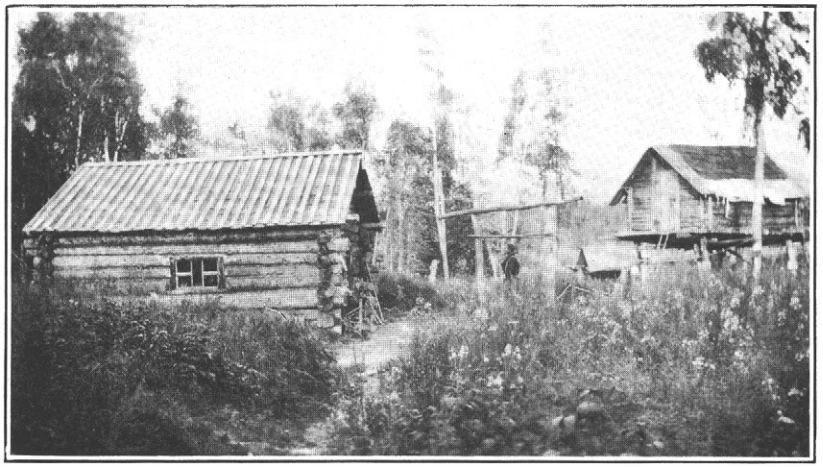
FIG. 1.—COTTONWOOD TREES, KENAI PENINSULA.

S8787

FIG. 2.—COTTONWOOD, BIRCH, AND SPRUCE FELLED BY FIRE, NEAR MATANUSKA JUNCTION.

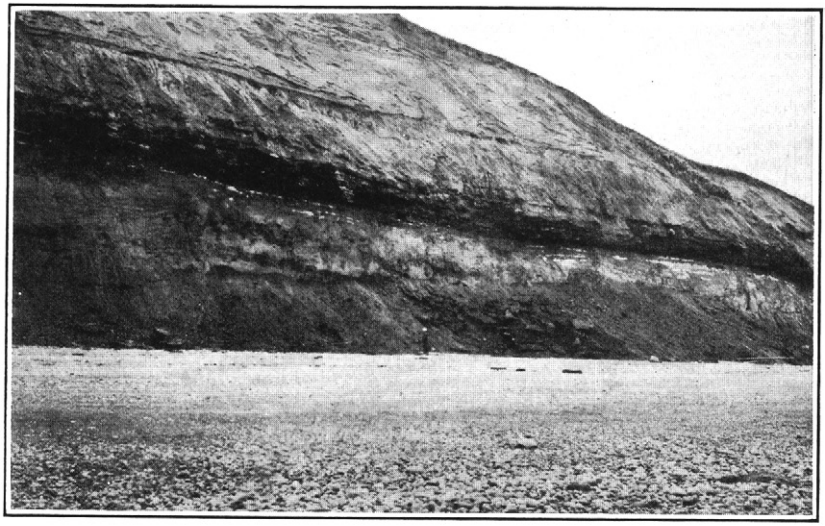
Note upturned roots. More land was burned over here than the homesteader is likely to use for several years.

FIG. 1.—CROSS TIES AND PILING FROM CHUGACH FOREST, ALONG GOVERNMENT RAILWAY EAST OF KNIK ARM.



S8634

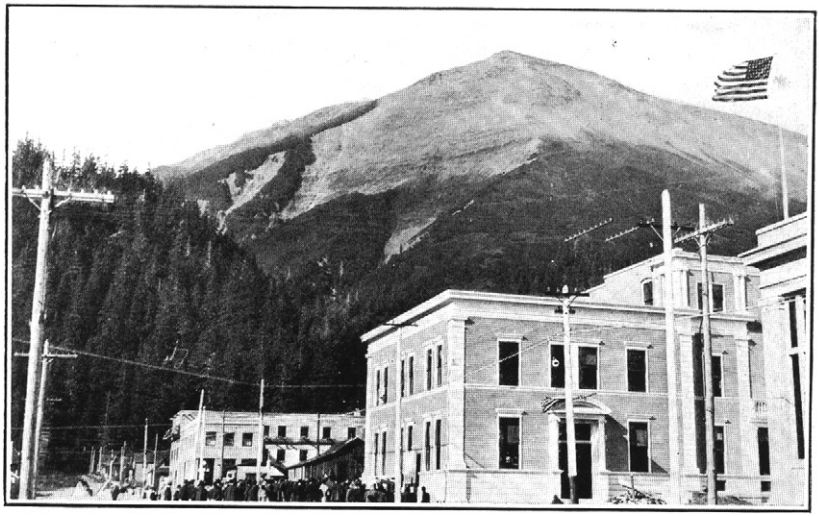
FIG. 2.—CABIN BUILT BY THE KINGS COUNTY EXPEDITION, NEAR THE MOUTH OF KINGS COUNTY CREEK ON SKILAK LAKE.



S8800

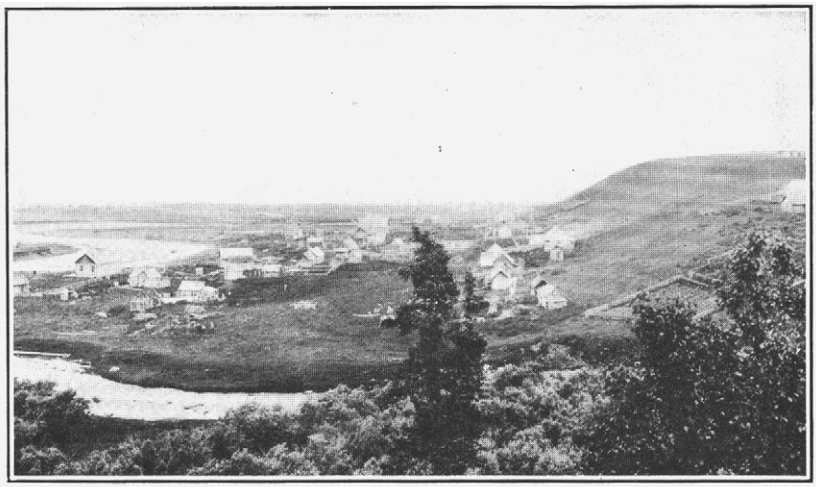
FIG. 1.—COAL (LIGNITE) SEAM, 8 TO 10 FEET THICK, IN MIDDLE OF BLUFF AT NINILCHIK.

This illustration also shows the clifflike character of the Kenai Peninsula bluff along Cook Inlet and the cobble-strewn beach.



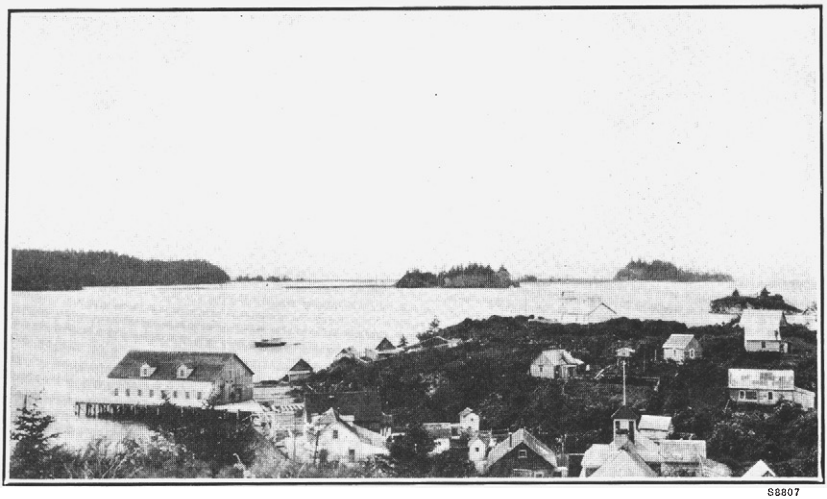
S8753

FIG. 2.—SALE OF TOWN-SITE LOTS, SEWARD, SEPTEMBER 8, 1916.



S8806

FIG. 1.—VIEW OF THE TOWN OF NINILCHIK.



S8807

FIG. 2.—ENTRANCE TO SELDOVIA BAY.

The building in the middle distance is a church.

more and more unnecessary, except in the case of prospectors who go far out into the wild mountainous country.

MEANS OF COMMUNICATION.

The Kenai Peninsula is nearly surrounded by navigable water, Cook Inlet reaching through Turnagain Arm, to within about 9 miles of the head of Passage Canal (or Portage Bay). Along the eastern and southern shores of the peninsula there are numerous deep-water bays and fiords, which make excellent harbors. The mud flats of Kachemak Bay and Turnagain Arm and those about the mouths of some of the streams entering the inlet from the Kenai lowlands, although deeply covered with water at high tide, are exposed at low tide, so that only small boats can make some of the landings, and these must go in on the flood tide and out on the ebb. Large steamers ply regularly between Seattle, Wash., and Anchorage, on upper Cook Inlet, Seldovia, Seward, and other points on the peninsula, and along the southern coast of Alaska. The large steamers can not land at places like Ninilchik or Kenai, but occasional stops are made in deep water off Kenai, where mail and freight are transferred by smaller boats. These villages, the various settlements and canneries along the inlet, and Anchorage are connected by boats and cannery tenders which maintain an irregular service.

Kenai River can be navigated easily on high tides by small power boats to a point 10 or 12 miles above its mouth. Small boats occasionally run down the river from Kenai Lake to Kenai, but it is necessary to "line" them upstream, as the water is too swift for rowing or poling, there being a number of formidable rapids and many dangerous rocks. Small boats can ascend Kasilof River to Tustumena Lake, it is said, although there is some swift water here also. There are a number of small boats on Kenai Lake, which is navigable from the head to the lower end. Skilak and Tustumena Lakes, about 15 and 20 miles long, respectively, are deep bodies of water that would be navigable to boats of large size.

Navigation on Cook Inlet is impeded somewhat by the very strong tides, especially in the case of small boats, which can make little or no headway against the strong currents. Rip tides, wind, and, on Turnagain Arm, a bore, frequently offer difficulties to small boats. Small boats go over the mud flats at high tide, and if still at anchor on the ebb, they settle in the mud until floated by the next rise of tide. The extreme range between the lowest and highest tides of Turnagain Arm is probably 45 or 50 feet, according to information of the United States Coast and Geodetic Survey.[1] Navigation on the upper

[1] See Pacific Coast Tide Table of the U. S. Coast and Geodetic Survey.

part of the inlet is interfered with by ice in winter, making anchorage for large vessels uncertain at times, as far down as Fire Island. On upper Knik Arm navigation is closed by ice for a time during winter.

So far as the country along the shores of the peninsula is concerned, therefore, the means of supplying transportation are at hand. But there is practically no means of transportation through the interior, aside from the railroad from Seward, now open to Kern Creek on Turnagain Arm, 71 miles from Seward, and the several wagon roads and trails. (Pl. XI. fig. 2.) The roads from Sunrise, on Turnagain Arm, to Sunrise Station, at mile 34 on the railroad, and that paralleling the railroad for several miles out of Seward (Pl. XII) afford easy travel for wagons. The road from Seward is also used by automobiles. This road is being extended toward Kenai Lake, the intention being to carry it out to the lake to connect with the Sunrise Road. Roads have also been opened from the mouth of Lynx Creek to near the head of that stream, and from Hope several miles up Resurrection Creek to the placer diggings. There are a number of trails over which pack horses and foot travelers make good progress at any time. These mostly follow the creeks along which placer mining is or has been important and where prospects have been located. There is a good trail from Moose Pass Station on Upper Trail Lake, at mile 29 on the Government railroad across Moose Pass to Quartz Creek, thence up that stream by Summit Lake, and down Canyon and Sixmile Creeks to Sunrise, and still another from Sunrise along Turnagain Arm to Hope. There is also a good trail from the lower end of Kenai Lake to the mouth of Russian River, and a less distinct trail from this point down to Skilak Lake. These roads and trails were mostly built by the Alaska Road Commission.[1]

There are indistinct trails used by hunters, trappers, and prospectors, such as those leading out into the big game country from Skilak Lake, that leading toward the upper Chickaloon country from a point above Schooner Bend on Kenai River, and the one up Big Indian Creek. They are little used, and most of them end in the wilderness.

Summer travel through the trailless country is always difficult and slow, and there are many swift streams and deep lakes that require rafts or boats to cross. It is especially difficult traveling over the Muskeg, as the foot sinks deeply into the saturated peat at each step. In winter, however, when the ground is covered with snow and the lakes, streams, and bogs are frozen, one can travel rapidly nearly everywhere with dog sled.

[1] Three officers of the U. S. Army constitute the Alaska Road Commission. Col. W. P. Richardson has been president of the commission since its creation.

Mails are received at Seward and Anchorage every few days throughout the year by steamer and frequently at Seldovia and Port Graham. They are received less regularly at Kenai and other points. Navigation is never interrupted by ice on Resurrection Bay and Prince William Sound. Kenai Lake is said to freeze over about the 1st of January and to open in May.

It is not particularly difficult to build good roads through much of this country, especially through the Kenai lowland, except where there is much Muskeg, because of the abundance of easily procurable gravel and sand. Road construction through areas of Muskeg will probably be expensive, since to build substantial roads here may require the hauling of much gravel.

If farming is to develop in an important way in this country, substantial roads will have to be provided.

The Government railroad, when completed, will extend from Seward, on the head of Resurrection Bay, and the Pacific terminus of the railroad, northward through the Kenai Mountains to the head of Turnagain Arm, thence along the north side of the Arm to Anchorage, on Knik Arm, from whence it will run northeasterly through the lowlands to a point a short distance beyond Matanuska River. From this point one branch of the railroad will extend northeasterly up the Matanuska Valley, tapping the coal fields of that region, while the other branch will cross the Knik Arm lowlands in a westerly direction, thence swing in a northerly direction up the valley of the Susitna River, cross the Alaska Range through Broad Pass (at an elevation of 2,400 feet above sea level), follow down the Nenana River, passing through the Nenana coal field, to the Tanana, cross that river and proceed to Fairbanks. This is the principal town of the Great Tanana Valley. It will be 420 miles north of Seward by rail.

Construction on this railroad has proceeded from both ends of the line. Already the Matanuska coal fields have been reached, and much work has been done on the line between Matanuska Junction and Fairbanks.

SOILS.

The soil-forming materials of Kenai Peninsula are of several principal kinds, namely: (1) Glacial and residual material, (2) glacial-outwash material, (3) alluvial material, (4) marine sedimentary material, (5) wind-blown material, and (6) cumulose material.

The soils derived from glacial and residual material are confined to the Kenai Mountains, which have been overridden by glacial ice, a large area still being covered by glaciers. These huge masses of moving ice have ground and mixed the varied rocks of the region and left the material on the slopes from which the ice has receded. On the steeper and higher slopes there is little or no soil. It is on

the lower and gentler slopes and in saddlelike situations and on shelves that the deeper mantle of this material occurs. There is little but rock and snow at elevations above 4,000 feet, and not much soil above 3,000 to 3,500 feet. Presumably some residual material is associated with this glacial detritus; that is, material which has been formed by decay of the underlying rocks, but this is not a matter of much importance, especially since the mountain soils prevailingly appear to be of a rather uniform character and of equal responsiveness to vegetative growth under similar conditions of climate, topography, and drainage. Probably not half of the mountainous area on Kenai Peninsula is covered with soil. A very considerable part is occupied by glaciers and snowfields (see map of Kenai Peninsula), and much of the remainder consists of cliffs and slopes of bare rocks.

The principal soils of the mountain slopes (Talkeetna soils) consist of brown to dark-brown material, usually a loam, which passes into brown or greenish-brown material of about the same texture. The upper part of the soil often has the color of parched coffee, especially where there is much moss or a thick heather growth. In the subsoil there are present in some places fragments of rock.

The most important soils of the peninsula are those derived from the material occupying the benches, hillocks, and ridges, collectively known as bench lands. It is believed that the bulk of this material was (1) washed out from beneath the glaciers by streams that issued from them, and spread out as plains just as is now being done in front of Spencer and other glaciers (Pl. XIII, figs. 1 and 2), and (2) left as material piled up in front of receding glaciers.

Gravel is often left in front of glaciers in the form of hillocks and ridges when the ice recedes. Such deposits are well illustrated at Spencer Glacier, where great piles of gravel skirt the front of the ice. Here the material apparently was piled up by an advance of the ice and left in place with subsequent melting off of the front of the glacier. Much of this mass is underlain by ice near the front, and when this melts the gravel drops down, in places forming depressions and leaving the material with a surface characterized by potholes and irregularly shaped hillocks. When the glacier melts back farther than it again advances, a permanent land area with a pothole, billowy, or hillocky surface is thus likely to be formed. There are many areas through the Kenai lowland having such a surface. It sometimes happens that these gravel piles are cut away in part by water from the glacier so that hillocks and ridges of varied shape are left along with the potholes as conspicuous features on an otherwise flat plain.

It is not at all improbable that some of these bench lands represent morainal material deposited along the edges as the ice melted

away from the waning glaciers. The fact that most of the benches consist of a mantle of loam from a few inches to about 4 feet thick overlying gravel and sand indicates that the gravel after being placed was subsequently covered by relatively slow-moving water which deposited over it the layer of finer-textured material. This process is now taking place over the glacier plains or deltas of the region. Near the front of the glacier the material consists of small and large gravel, cobblestones, and bowlders, but farther down, where the water spreads out and flows at a slower rate, a layer of finer material, as sand and silt, is being deposited over the gravel. There has been some deposition of volcanic material over the region. Thus, for example, in 1912 ashes thrown up by the eruption of Katmai on the Alaska Peninsula fell throughout the Cook Inlet country. Mineralogical analyses of the soil material, however, do not show the presence of sufficient volcanic material—volcanic ash—to account for the surficial layer of fine material over the coarse subsoil or substratum material.

Martin et al.[1] make this statement concerning the origin of the surface materials in the Kenai Peninsula.

> The Quaternary deposits of the Kenai lowland are chiefly if not wholly of glacial origin and were evidently laid down at about the time of the maximum glaciation of the district. They consist of a basal and, in general, thick sheet of till, in most places overlain by stratified sands and gravels whose surface is well terraced. These deposits extend throughout the greater part of the Kenai lowland and are strikingly different from the glacial deposits of the Kenai Mountains. The glacial deposits of the mountains are very thin and irregular and are closely related in volume and character to the local topographic and lithologic features. They are the characteristic products of a system of local actively eroding alpine glaciers. The glacial deposits of the lowland are such as would be laid down near the lower end of a large stagnant ice mass whose load had been derived from many sources and had been carried far, finely ground, and deposited not only by the melting away of the glacier itself but by the action of streams that were bringing large amounts of glacial detritus from more or less distant points.

The sand, gravel, cobblestones, and bowlders constituting the main portion of the subsoil and substratum of the bench lands come from varied sources, as shown by the great variety of rocks represented, such as granite, quartz, greenstone, conglomerate, graywacke, and others.

In places the subsoil or upper subsoil contains considerable clay. These finer sediments may have accumulated through deposition from glacier water standing in depressions. The areas seen containing so much clay were small.

[1] Martin, G. C., Johnson, B. L., and Grant, U. S., Bul. U. S. Geol. Survey No. 587, p. 95, Geology and Mineral Resources of Kenai Peninsula, Alaska.

The principal soils of the bench lands (Knik soils) are brown in the surface portion, grading beneath into light brown or yellowish brown and resting at depths ranging from a few inches to 3 or 4 feet upon a yellowish-brown to greenish-brown mass of gravel and finer material. (Pl. XIV.) This gravelly stratum usually becomes coarser and looser with increase in depth. The upper part is often a gravelly loam and the lower part a loose mixture of sand, gravel, and cobbles, with bowlders frequently present below 3 feet. In many places there is a stratum of sand or sandy loam immediately over the gravelly bed. Where there is much moss or leaf mold the soil to a depth of several inches is commonly the color of parched coffee. There is usually at the surface or just beneath the moss or leaf mold a gray silty layer from a fraction of an inch to about 3 inches thick. The loam and silt loam soils predominate.

The Knik soils are very much like the Plainfield and Merrimac soils occurring through the New England States, the Adirondack portion of New York, and in Wisconsin and Michigan, except that the gray surface layer and the frequent coffee-brown subsurface of the Knik soils are absent in the Plainfield and Merrimac. The gray surficial layer is common in soils of northern Maine[1] and in many instances a coffee-colored layer is encountered there. In other respects the Knik soils are much like the Merrimac, both in manner of formation, character of material, and profile, structure, and drainage features. The Merrimac series includes light-brown or grayish surface soils underlain by grayish-brown or yellowish subsoils which are usually lighter in texture than the surface material. The deeper subsoil consists of stratified sand and gravel. The soils forming this series are confined to the glacial region and occur as glacial outwash plains, glacial terraces, and filled-in valleys. The parent material has been derived largely from crystalline rocks consisting chiefly of granite and gneiss. The surface is level to very gently undulating. Because of the loose character of the subsoil the drainage usually is thorough, and sometimes excessive. The Plainfield soils are much the same physically, but the material is derived mainly from sandstone. The Knik soils also closely resemble the glacial-outwash bench lands of western Washington, west of the Cascade Mountains.[2]

Soils of the Knik series are mainly developed below timber line, but they are found also to some extent on high benches considerably above timber line.

Associated with the bench lands are occasional patches of soil referred to above, which have a gray or bluish-gray rather compact

[1] See description of Caribou loam, Soil Survey of the Caribou Area, Maine, Field Operations of the Bureau of Soils, U. S. Dept. of Agriculture, 1908.

[2] See Reports on reconnoissance soil surveys of southwestern Washington and of the western part of the Puget Sound Basin, Washington, Field Operations of the Bureau of Soils, U. S. Dept. of Agriculture, 1911 and 1910, respectively.

silty clay or silty clay loam subsoil, or at least upper subsoil. This silty clay stratum often extends to depths of more than 3 feet, but in places gravelly material is reached at less than 3 feet. Soils of this kind (Kenai soils) are much less extensive than those with the gravelly subsoil. The loam and silt loam are the principal types. These soils seem to have good drainage, although the compact subsoil may interfere somewhat with internal circulation of moisture and air.

In some wet flats and on slopes where there is considerable seepage there are, in the bench-land country, some areas, usually not extensive, that have a black mucky soil and brownish to greenish-brown subsoil, underlain by gravelly material. Soil of this nature has been given the name Chickaloon. The loam is the principal type.

Another class of soil material is represented by the sediments deposited in stream bottoms; that is, recent alluvium. (Pl. XV, fig. 1.) Here the material is of several kinds and has come from the mountain and bench soils and from the material underlying the bench soils, such as the common lacustrine or marine blue clay and silt, where the streams have cut down through the benches to such beds. These materials are carried in suspension by the stream water and swept along the bottoms of the channels. At high-water stages they are spread out over the flood plains. Many of the streams no longer overflow except when ice jams form during the breaking up of the ice in spring. The bottoms of the glacier streams are occasionally inundated during summer. Where the streams have cut down rapidly, as through the soft beds of the Kenai lowland, flood plains have not been formed, so that many of them flow through steep-walled trenches or canyons. Neither have flood plains been formed along the mountain streams of rapid fall.

The stream bottom soils (Susitna soils) are of a bluish or bluish-brown color and are usually sandy or gravelly in the subsoil. The lower subsoil or substratum characteristically is coarser textured than the overlying material, ranging from fine sand to a mixture of sand and gravel. The material consists of stream-borne sediments spread out over the flood plains. Along many streams, such as Glacier Creek entering Tustumena Lake, the material has not been carried far after being washed from beneath the glacier. No glaciers now exist at the heads or on any of the tributaries of many of the streams, although glaciers formerly existing there may have contributed much of the alluvium, particularly of that lying on the high bottoms not now subject to overflow. In the lower bottoms some of the present material consists of recently deposited alluvium washed from the soils over which the drainage waters flow, but there is much less of such wash material than in the bottoms of regions including much cultivated land, because so much rainfall is absorbed by the soil and

the run-off is slow and but lightly burdened with suspended material. The drainage of the alluvial areas between periods of overflow is prevailingly good to excessive in case of the deeper loose sandy and gravelly types. Often the surface is rich in organic matter and is dark colored. Fine sand, silt loam, silty clay loam, and gravelly sand are the principal types.

Still another class of material is that which has been transported by wind. Along the edges of the benches fronting on Cook Inlet there are frequently found strips of quite sandy soil that grades off into the usual loam back from the shore line and that passes beneath into heavier material. The sand here probably was blown up from the beaches below. On the north side of Kachemak Bay there are deep beds of silt and very fine sand in which no gravel was found in exposures of more than 100 feet thickness. (Pl. XV, fig. 2.) The benches here are thus markedly different from those seen elsewhere in the region, and it is possible that they have been formed of wind-blown particles, although this can not be stated positively.

The soils that appear to be composed of such wind-blown material are brown to coffee brown in the surface and yellowish brown in the subsoil, with but little or no textural change from the surface downward. The surface is a darker brown in color because of the organic matter present. The drainage is well established. Soil of this kind has been given the name Kachemak. The very fine sandy loam is the predominant type.

A very distinct class of material consists of accumulations of vegetable matter in the muskegs and muck bogs. The peat consists entirely of vegetable matter, is fibrous in structure, and usually brown in color. Muck represents more thoroughly decayed vegetable matter mixed with some soil material and is always black in color.

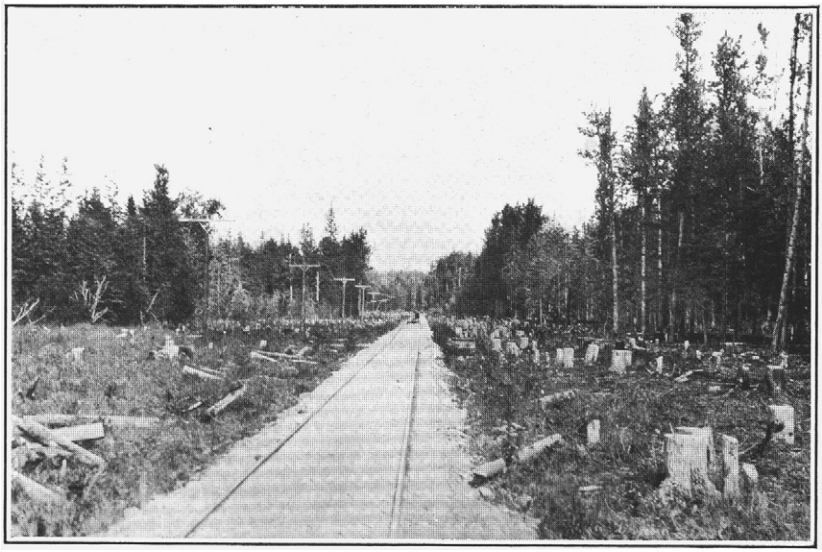
On the flats (mud flats) bordering tide water there are areas of bluish silty clay loam and silt loam subject to tidal inundation. (Pl. XVI, fig. 1.) On the higher areas which are inundated only at times of exceptional high tides the soil has been darkened some by the vegetation present. As a rule, however, there is little change from the surface downward, except for some brownish mottlings or streaks in the subsoil apparently the results of oxidation following the lines of plant roots. Most of this material runs high in content of water-soluble salts, mainly sodium chloride, and salt-loving plants are commonly present. These mud flats represent silt and clay, accumulated about the mouths of rivers and at the heads of the arms and bays, deposited in salt water, that is, marine water.

A feature common to all the soils of this region except peat, muck, and mud flats which are not normal soils, is the presence at the surface or immediately beneath the covering of leaf mold or moss of

S8730

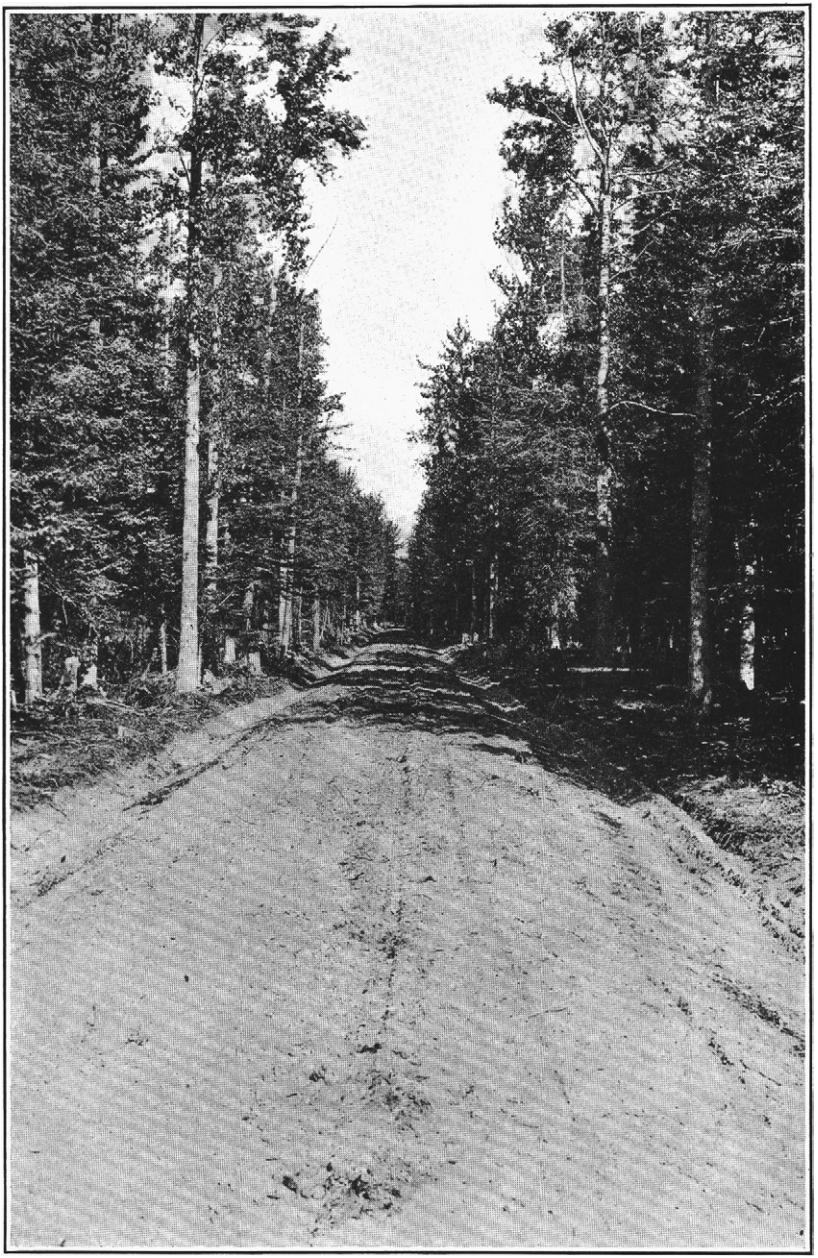
FIG. 1.—SPRUCE-LOG CABIN AND VEGETABLE GARDEN ON SKILAK LAKE.

In this garden were growing cabbage, lettuce, beets, turnips, etc.



S8749

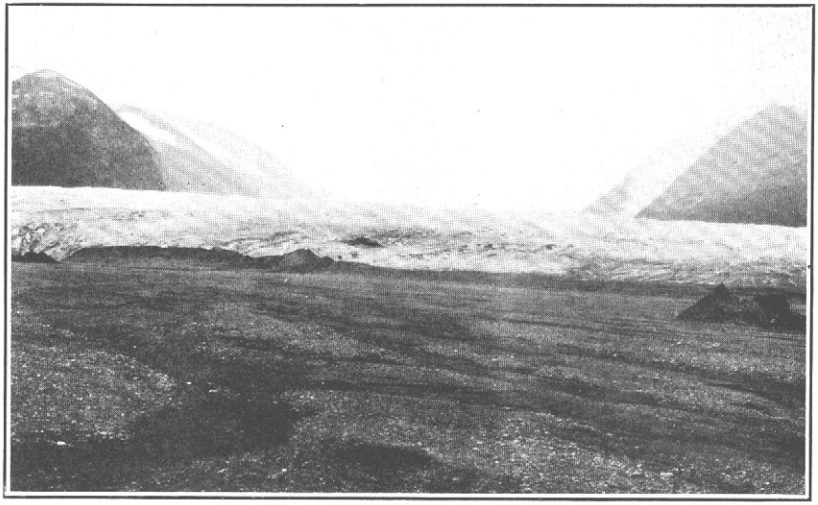
FIG. 2.—SECTION OF GOVERNMENT RAILWAY NEAR SEWARD.



S8751

ON ROAD BUILT BY ALASKAN ROAD COMMISSION, ABOUT 5 MILES NORTH OF SEWARD.

Forest consists of cottonwood, spruce, and hemlock. Soil, Susitna fine sandy loam.



S8599

FIG. 1.—OUTWASH PLAIN, SPENCER GLACIER, WITH SMALL ISLANDLIKE GRAVELLY HILLOCKS.

This material washed from beneath glacier by water.

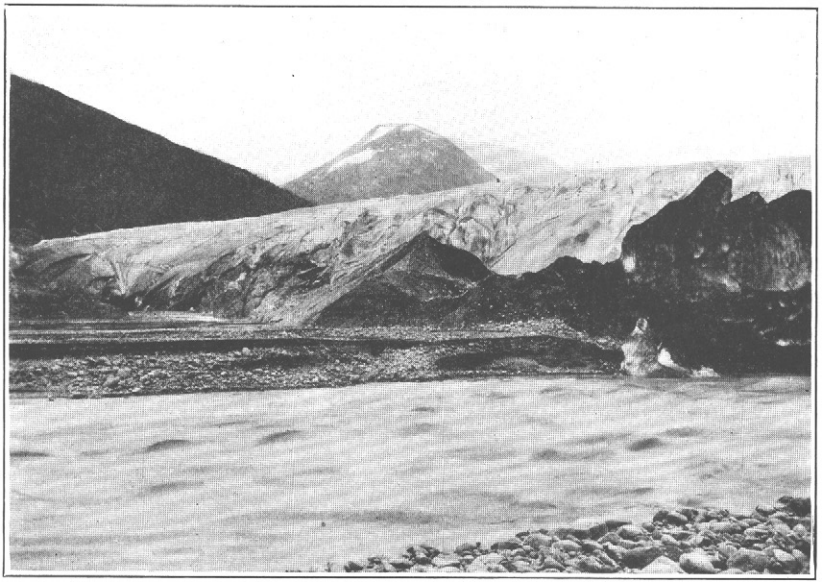


FIG. 2.—SHOWING GRAVEL PILED IN FRONT OF SPENCER GLACIER.

The stream in the foreground issues from beneath the ice. Streams of this character carry large quantities of silt, sand, gravel, and bowlders and deposit them on outwash plains.

S8785

CHARACTERISTIC GRAVELLY SUBSTRATUM OF THE BENCH LANDS OF THE COOK INLET COUNTRY.

This illustration shows a section of the deep Knik loam near Matanuska Junction, on the Government Railway. The soil above the gravel stratum is about 3½ feet deep.

a thin layer of light-gray silt loam or silty loam. In some places this layer is 3 inches thick; frequently it is less than an inch, but it is rarely absent, although in those places kept wet by seepage and in burned areas it may be nearly indistinguishable. This gray layer is locally looked upon as consisting of volcanic ash, and usually the entire stratum of fine material overlying the gravel, sand, and cobblestones is thought by the inhabitants to be volcanic ashes; but, as pointed out above, only a portion of the material represents volcanic ash. The gray layer at the surface may owe its color to chemical changes brought about by leaching from the overlying leaf mold.

Since the placing of the soil-forming material by the action of glaciers and running water, there have been changes in the material, mainly through the influence of air and vegetation. Decaying vegetable matter has intermingled with the surface soil to give it a darker color—different shades of brown in the better drained and black in the more poorly drained situations. The air, through oxidation, has tended also to produce the brownish color in the soils, as evidenced by the browner color of the material in the better drained situations, even in the subsoil, as compared with the bluish-colored subsoil material of the wet mud flats. There are not in this region, however, the variety of soil colors, originating apparently from different degrees of oxidation, found in some regions, as, for example, in the Coastal Plain of southeastern United States, where bright-red, dull-red, yellow, gray, and black soils occur in close association, but under different conditions of drainage. In this cool climate oxidation probably is much slower than in southern United States.

Also there are not found here soils with colors conforming to the color of the rocks, as is frequently true in those regions where the soils represent material formed in place by decay of the underlying formations. At least such soils were not seen. Here there probably has been too much mixing of the material by glaciers and water to allow much color variation due to derivation from different rocks.

The soils of the region, with the exception of the tide flats and an occasional unimportant salt lick, are strongly acid. Chemical analyses show that while the soils have a good content of lime—more than many of the best farming soils of the humid portion of the United States contain—the lime is not present in the form of carbonates, but probably in combinations of low solubility, since very liberal quantities of lime must be added to correct the acidity.[1]

Results of chemical analyses given in the following table also show the soils to have a good or normal chemical composition as compared with important farming soils of the United States. These

[1] See Soil Reconnoissance of Alaska, Field Operations of the Bureau of Soils, U. S. Department of Agriculture, 1914, p. 96.

analyses were made by the fusion method, and therefore show the total quantities of the various constituents in the soils. This method does not distinguish between soluble and insoluble constituents, but the favorable yields of crops and rank growth of vegetation, under favorable conditions, can be taken as measuring, in some degree, the availability of plant food. For comparisons, the results of chemical analyses of several important farming soils of the United States are also presented.

Results of mechanical analyses of several samples of representative soils in the region are given under the descriptions of the soil types in the following chapters. In these chapters the soils are described in detail, and their agricultural value is brought out so far as this can be done with the information at hand.

Chemical analyses of important soils of the Kenai Peninsula region, Alaska—Fi

Soil type and part of vertical section.	No. of sample.	Location of sample.	SiO_2.	$Fe_2O_3 + Al_2O_3$.	SO_3.	TiO_2.	CaO.	MgO.	Na_2O.	K_2O.
Knik fine sandy loam, deep phase:			*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Surface soil	[2] 590, 201	3 miles northeast of Salamatof Creek, Kenai lowland.	58. 55	19. 31	0. 17	.....	3. 30	1. 92	3. 30	1. 40
Subsurface	[2] 590, 202	.....do.....	56. 20	21. 31	. 18	.....	3. 77	1. 47	3. 72	1. 50
Upper subsoil	[2] 590, 203	.....do.....	59. 83	21. 07	. 12	.....	2. 35	1. 74	3. 46	1. 33
Knik silt loam:										
Surface soil	[2] 590, 205	2½ miles above mouth of Anchor River, Kenai Peninsula.	58. 17	19. 63	. 15	.....	2. 70	1. 69	2. 96	1. 32
Subsoil	[2] 590, 206	.....do.....	63. 78	22. 30	. 08	.....	2. 65	1. 83	3. 08	1. 39
Knik fine sandy loam:										
Surface soil	[2] 590, 207	1 mile above mouth of Cooper Creek, Kenai Peninsula.	57. 88	21. 57	. 12	.....	2. 19	1. 45	3. 20	1. 57
Subsoil	[2] 590, 209	.....do.....	60. 96	22. 40	. 25	.....	3. 10	1. 79	3. 06	1. 63
Knik very fine sandy loam:										
Surface soil	[2] 590, 210	Point Possession, Kenai Peninsula.	66. 16	16. 68	. 18	.....	2. 86	1. 34	2. 86	1. 16
Subsurface	[2] 590, 211	.....do.....	60. 83	14. 58	. 25	.....	2. 39	. 98	2. 54	1. 16
Upper subsoil	[2] 590, 212	.....do.....	62. 33	18. 38	. 22	.....	2. 49	1. 16	2. 66	1. 14
Lower subsoil	[2] 590, 213	.....do.....	61. 25	20. 66	. 19	.....	2. 72	1. 85	2. 72	1. 22
Mud flats	[2] 590, 216	Hope, Kenai Peninsula....	60. 80	22. 96	. 27	.....	2. 02	2. 79	2. 94	1. 87

[1] Analyses made in the laboratory of the Bureau of Soils, and stated on air-dry ma

[2] Analyses by William Hazen.

Chemical analyses of important soils of the Kenai Peninsula region, Alaska—Fusion

Soil type and part of vertical section.	No. of sample.	Location of sample.	SiO_2.	Fe_2O_3 + Al_2O_3.	SO_3.	TiO_2.	CaO.	MgO.	Na_2O.	K_2O.
Susitna fine sandy loam:										
Surface soil	[2] 590, 217	1 mile above mouth of Sunrise Creek, Kenai Peninsula.	49.84	21.50	.23	.....	1.36	1.77	2.52	1.48
Subsoil	[2] 590, 218	.....do.....	59.40	24.64	.17	.....	1.34	2.60	2.62	2.17
Knik silt loam, deep phase:										
Surface soil	[2] 590, 224	½ mile north of Matanuska Junction, Matanuska Valley.	63.08	20.57	.19	.....	3.26	1.60	3.02	1.25
Subsoil	[2] 590, 225	.....do.....	60.32	21.00	.19	.....	2.92	1.92	2.94	1.03
Deep subsoil	[2] 590, 226	.....do.....	60.57	22.84	.16	.....	2.80	2.44	2.84	1.06
Knik silt loam, shallow phase: Surface soil.	[2] 590, 231	3 miles northeast of Anchorage, east side Knik Arm.	61.27	.....	.17	0.76	2.55	1.48	2.82	1.18
Knik silt loam: Surface soil.	[2] 590, 233	Kenai, Kenai Peninsula (experiment station pasture).	59.50	.....	.22	.67	2.69	1.44	2.77	1.27
Kachemak very fine sandy loam:										
Surface soil	[2] 590, 238	1 mile above mouth of Swift Creek, Kenai Peninsula.	61.25	.....	.23	.76	3.04	1.44	3.10	1.48
Subsoil	[2] 590, 239	.....do.....	63.02	.....	.16	.79	2.88	1.58	3.10	1.63
Chickaloon loam: Surface soil.	[3] 590, 249	North side of Bear Cove, Kenai Peninsula.	61.27	.....	.34	.81	2.30	1.50	2.48	1.14

Talkeetna loam: Surface to bedrock, 0 to 3 nches.	[4] 590,245	Near Fork of Benjamin and Killey Rivers, Kenai Peninsula (3,200 feet elevation—upper limit of soil).	60.58	.....	.28	.66	1.81	2.16	1.86	.92
Knik loam: Surface soil..	[4] 590,247	Mouth of Cottonwood Creek on Skilak Lake, Kenai Peninsula.	61.51	.....	.50	.66	2.06	1.22	1.84	.85
Susitna silty clay loam: Surface soil.	[4] 590,251	2 miles northeast of Anchorage, east side Knik Arm.	62.46	.....	.64	.73	2.23	2.43	2.46	1.61
Knik loam, deep phase: Surface soil.	[4] 590,256	On high bench just south of Ninilchik, Kenai Peninsula.	56.47	.....	.28	.66	3.46	1.82	2.55	1.07
Susitna silt loam: Surface soil.	[3] 590,258	Copper River flats, Prince William Sound.	62.44	.....	.34	.84	3.86	2.95	2.77	1.79

[1] Analyses made in the laboratory of the Bureau of Soils, and stated on air-dry m
[2] Analyses by William Hazen.
[3] Analyses by R. F. Gardiner.
[4] Analyses by L. A. Steinkoenig.

Chemical composition of important types of soil in the United States [1]—*Fu*

Soil type and section.	No. of sample.	Location of sample.	SiO_2.	Fe_2O_3.	Al_2O_2.	TiO_2.	CaO.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Norfolk sandy loam:							
Soil	1	Eastern North Carolina (Coastal Plain).	94.50	0.83	2.07	0.71	0.39
Subsoil	2	.....do.....	85.30	1.91	8.82	.91	.38
Decatur clay loam:							
Soil	3	Northeastern Alabama (Limestone Valleys).	79.35	4.44	8.89	1.15	.63
Subsoil	4	.....do.....	74.81	5.28	12.80	1.28	.40
Marshall silt loam:							
Soil	9	Northwestern Missouri (Loessial region).	73.61	3.54	9.67	.71	1.08
Subsoil	10	.....do.....	71.43	4.28	13.44	.77	1.40
Gloucester stony loam:							
Soil	11	Southern New Hampshire (Glacial region).	65.68	5.67	14.15	.79	1.36
Subsoil	12	.....do.....	73.80	4.37	13.24	.71	1.19
Carrington loam	13	Southern Wisconsin (Glacial region).	73.50	4.30	9.10	.59	.94
Cecil clay:							
Soil	15	Southern North Carolina (Piedmont Plateau).	66.49	7.43	17.11	1.02	.36
Subsoil	16	.....do.....	44.5	16.23	27.58	1.14	.44

[1] These analyses are taken from Bul. No. 122, U. S. Dept. of Agriculture, The Inorganic Composition of Some

Except in the 3-mile strip along Cook Inlet from East Foreland to the head of Kachemak Bay, which was surveyed in detail, the soil map covering the lowlands portion of the Kenai Peninsula is more generalized than was the map published in the reconnoissance report on Alaska soils made by Rice and the author in 1914. The former map was based partly upon information obtained by reconnoissance timber cruises. From the information secured during our expedition in the Kenai lowlands in 1916 it is deemed best to show on the map only generalized soil divisions. Much careful detailed work would be required to show the soils as accurately as they are shown in the 3-mile strip along the shore of Cook Inlet. The base map used for the Kenai Peninsula soil map was made by the United States Geological Survey. Without the aid of this base it would not have been possible to show the soils with as much accuracy as has been done.

The Knik Arm strip is mapped in detail, so that there will be no necessity for further detail work here.

No attempt has been made to show soil areas in the Prince William Sound region, since the work done there was too generalized. The location of some of the more important soil areas of the Sound country having topographic features favorable to cultivation are briefly referred to in the general description of the Prince William Sound region.

The areas of the several soils in the two more detailed maps accompanying this report are given in the following table. These cover only a small part of the Kenai Peninsula.

Areas of different soils.

Soil.	Acres.	Per cent.
Knik Arm strip:		
Knik loam, shallow phase	17,856	45.0
Knik loam	9,216	23.2
Knik loam, medium-deep phase	4,992	12.6
Muskeg	4,928	12.4
Mud or tide flats	1,856	4.7
Susitna soils (alluvial)	832	2.1
Total	39,680	.....
Kachemak Bay, East Foreland sheet:		
Knik loam	25,728	47.3
Muskeg	13,632	25.0
Kachemak very fine sandy loam	5,248	9.6
Kachemak very fine sandy loam, lower areas, and smoother slopes	4,032	7.4
Steep slope land	2,048	3.8
Low benches and slopes of Knik soils and gravelly beach	1,856	3.4
Mud or tide flats	1,280	2.4
Kachemak very fine sandy loam, colluvial flats, and slopes	384	.7
Susitna soils (alluvial)	192	.4
Total	54,400	.....

KNIK FINE SANDY LOAM.

The Knik fine sandy loam is not an important soil, at least in those parts of the Kenai lowlands visited, for the reason that it is not extensive. It was found in a number of places on the benches fronting on Cook Inlet and on some of the low benches near Kenai River.

The typical soil, as seen on the second bench above the bottoms of Kasilof River, 3 miles up from the mouth, consists of gray loam to silt loam about one-half to 2 inches deep, overlying brown loam, which grades at 3 or 4 inches into yellowish-brown silty fine sandy loam, and this at about 10 inches into greenish-brown loam or silt loam, with greenish-brown fine sand or loamy fine sand appearing at 15 to 20 inches. In the lower part of the 3-foot section gravel is usually present. The strips along Cook Inlet appear to represent areas of Knik loam, over which fine sand has drifted from the beaches below. A representative area of this kind at a point 3 miles northeast from the mouth of Salamatof Creek consists of about 8 inches of brown fine sandy loam overlying brownish-yellow loam to silt loam, which at about 20 inches passes into greenish-brown or pale-olive silt loam, underlain at 24 inches by greenish-brown gravelly sandy loam.

The soil is acid, contains considerable organic matter, and supports the same kind of vegetation as the Knik loam. The drainage conditions also appear to be similar to those of the Knik loam. Its surface, however, is flat in most cases. Under cultivation this soil may be expected to give about the same results as the Knik loam. The loose sandy soil may dry out quicker than the loam, so that there may be greater need of replenishing the supply of humus by growing the legumes or other humus-supplying crops or by adding manures.

The following table gives the results of mechanical analyses of samples of the soil, subsurface, upper subsoil, and lower subsoil of the Knik fine sandy loam:

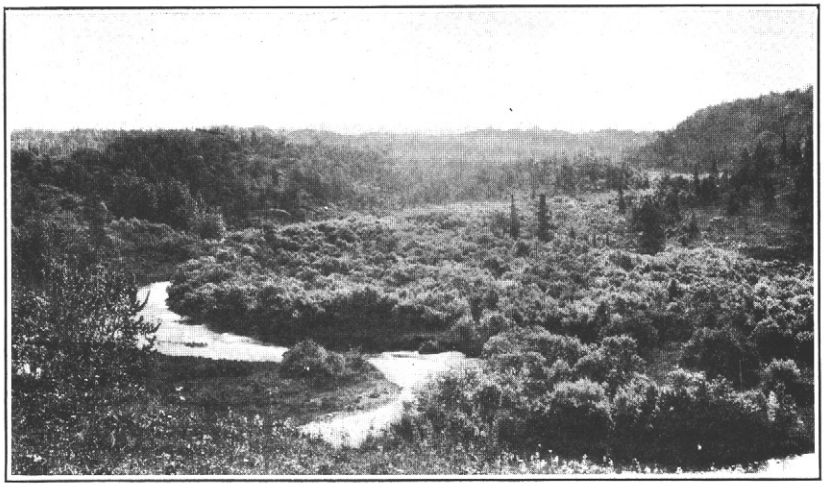


FIG. 1.—NARROW BOTTOM ALONG SMALL STREAM, JUST ABOVE NINILCHIK.

The soil here is of recent alluvial origin.

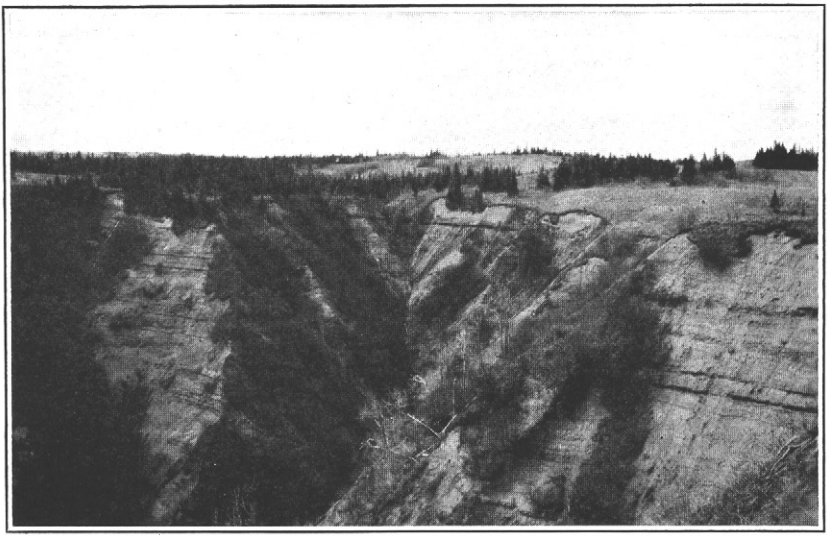
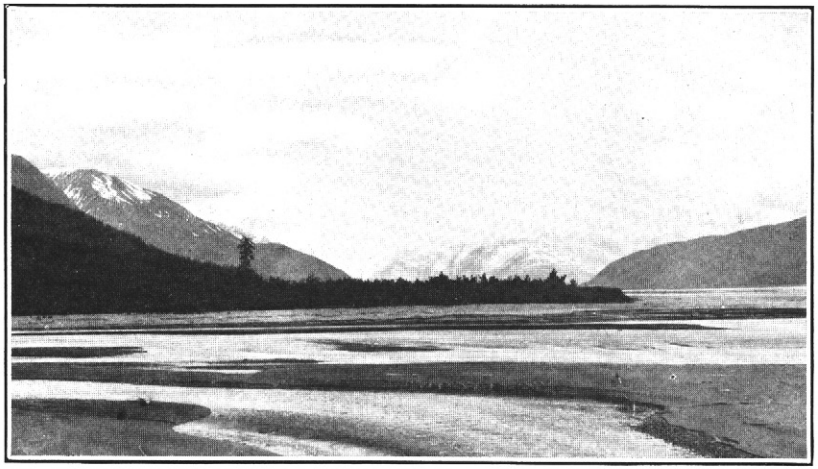


FIG. 2.—GRASS-COVERED HIGH BENCH, DOTTED WITH CLUMPS OF SPRUCE AND FLANKED BY BARE OR ALDER-COVERED SLOPES, ON SWIFT CREEK, NEAR THE HEAD OF KACHEMAK BAY.



S8743

FIG. 1.—MUD FLATS ALONG TURNAGAIN ARM AT THE MOUTH OF GLACIER CREEK.

These flats have not yet been built high enough to enable vegetation to secure a foothold, and are not shown on the soil map. They are covered daily at high tide.

S87w2

FIG. 2.—VEGETABLE GARDEN ON SLOPE OF BENCH LAND (DEEP KNIK LOAM) NEAR MATANUSKA JUNCTION.

Mechanical analyses of Knik fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
590207	1 mile above mouth of Cooper Creek near Homer, Kenai Peninsula.	Soil, brown fine sandy loam, 0 to 12 inches.	0.7	4.4	4.9	26.8	18.5	29.8	15.2
590208	.....do.....	Subsoil, brown loam to gravelly loam, 12 to 30 inches.	.8	5.0	6.1	30.6	17.2	30.0	10.3
590242	3 miles above mouth of Kasilof River, Kenai Peninsula.	Soil, brown loam to fine sandy loam, 0 to 10 inches.	.2	4.4	7.2	26.8	13.8	38.6	9.0
590243	.....do.....	Subsurface, brown loam, 10 to 18 inches.	.0	1.2	2.6	16.3	16.7	53.8	9.5
590244	.....do.....	Subsoil, brown fine sand with gravel, 18 to 36 inches.	.4	3.8	11.4	57.2	7.0	16.4	4.0

KNIK VERY FINE SANDY LOAM.

In a few places on the benches skirting Cook Inlet Knik very fine sandy loam was found. This very closely resembles the Knik fine sandy loam, occurring in similar positions. The subsoil is the same as that of the Knik loam. It is believed the sandy material was drifted from the beach of Cook Inlet.

More of this soil was seen between Point Possession and the Indian cabins just southwest of the point than elsewhere. A typical vertical section here consists of brownish-gray to brown very fine sandy loam, underlain at about 8 inches by coffee-brown or brownish-yellow loam to very fine sandy loam, which, in turn, passes at about 14 inches into yellowish-brown loam, this grading into greenish-brown or pale-olive silt loam at depths between 20 and 30 inches. When dry the soil is grayish and fluffy. No gravel was found in the Point Possession area within 40 inches of the surface, but in other places gravelly material was encountered within the 3-foot section.

At Point Possession the type supports a heavy stand of large spruce, with some birch and the usual undergrowth, moss, and redtop.

In use this soil may be expected to give about the same results with crops as the deep Knik loam. While the soil is a little coarser in the surface portion, the subsoil is essentially the same as that of the deep Knik loam, and since the sandy surface soil ordinarily is only about 6 to 8 or 10 inches deep, there very likely would not be much difference in the moisture-holding capacity. The very fine sandy loam

possibly has an advantage in that the more open soil would admit of more thorough aeration and perhaps get into a good productive condition quicker. On the other hand, shallow-rooted crops might suffer to some extent in event of long periods of dry weather.

Apparently there is not much of this soil, and it is, therefore, of no great importance. The following table gives the results of mechanical analyses of samples of the soil, subsurface, upper subsoil, and lower subsoil of this type:

Mechanical analyses of Knik very fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
590210	Near Indian Village on Point Possession, Kenai Peninsula.	Soil, light gray, very fine sandy loam, 0 to 8 inches.	0.2	0.3	0.9	12.1	43.8	34.1	8.2
590211	.....do.....	Subsurface, coffee-brown loam, 8 to 14 inches.	.0	.6	1.0	10.9	35.2	35.6	16.8
590212	.....do.....	Subsoil, yellowish and brownish loam, 14 to 20 inches.	.2	.4	1.0	8.8	32.7	46.6	10.6
590213	....do.....	Lower subsoil, greenish-yellow silt loam, 20 to 40 inches.	.4	.6	.6	4.2	23.4	63.8	7.3

KNIK LOAM.

The Knik loam is the most extensive and important soil of the Kenai lowland benches; it is likewise the most extensive and important soil of the entire Cook Inlet plain or lowland country.[1] Locally this type of soil is known as "bench land," "volcanic ash," and, in the Matanuska Valley, as "Matanuska loam" and "Matanuska soil." It was given the local name Knik loam because it was first studied in 1914 in the vicinity of Knik, Alaska.[2]

In texture this soil varies from loam to silt loam. Much of it will analyze a definite loam and much a definite silt loam, and in a detailed soil survey the latter would be mapped as Knik silt loam; but the difference in content of silt, ranging up to as much as 15 or 16 per cent more silt in the silt loam than in the loam, does not seem to be of very great importance here in so far as affecting the growth of plants. Everywhere the soil contains enough fine and very fine sand to impart a distinctly mellow or loamy nature to the material, giving it that texture and structure possessed by a typical loam type

[1] See Soil Reconnoissance in Alaska, Field Operations, Bureau of Soils, 1915.
[2] Loc. cit.

of soil. Variation in depth to the underlying gravel is of much more importance than variation in the silt content, and therefore the soil will be considered as one type in this report.

Aside from the variation in physical composition and in depth to gravel, the Knik loam possesses certain characteristics of marked uniformity. There is nearly always present a thin surface covering beneath the leaf mold or moss, consisting of gray loam or silt loam, less than an inch to 3 or 4 inches thick, and beneath this is always found a brown mellow loam or silt loam which becomes lighter below and passes abruptly into yellowish-brown, greenish-brown, or pale-olive gravelly loam or first into pale-olive or greenish-brown fine sandy loam or loamy fine sand and then into gravelly loam. The gravelly stratum usually becomes coarser and looser with increase in depth, until a mass of fine and coarse gravel and in places cobblestones, with an admixture of sand is reached. In the deeper substratum larger bowlders are not uncommon. The gray surface layer is not found in some places, as in portions of the burned-over areas and in those places where an exceptionally moist condition has favored the accumulation of dark-colored mucky material at the surface. In these places the gray layer may simply have been obscured by staining or by an admixture of ashes and soil or by oxidation caused by the fire. The brown material, the color of which resembles parched coffee or coffee grounds, is most commonly encountered in rather moist situations, on northern slopes, on the higher benches, and in those places where there is a deep covering of moss or leaf mold.

The gravelly material extends to undetermined depths, except as seen in some of the escarpments, as those along Cook Inlet. At Ninilchik, for example, this gravel is exposed in a cliff probably 200 feet high. In exposed sections the material is seen to vary from gravelly loam to a mixture of sand, gravel, cobblestones, and bowlders. It also includes coal seams, the thickest of which is about 6 to 8 feet at this place. In the high cliff at Kenai there is, below 150 to about 200 feet, a basal stratum of gravelly material, which consists of a bluish silty clay loam to heavy silt loam.

The depth to the coarser textured subsoil or substratum ranges from about 5 inches to 4 feet, but by far the greater part has the coarser material at depths of less than 3 feet, and there are many shallow areas, some of them extensive, where the gravelly material is reached at 5 to 12 inches. In the country examined most of the soil has the gravel at depths ranging from about 10 to 20 inches. There are also many bodies of the deep phase, having the gravelly stratum at depths ranging from about 20 to 36 inches, with occasional areas in which it is deeper than 3 feet. Much of the soil in Matanuska Valley is 3 feet deep or more, and the same deep soil was

found in the Kenai lowland at Point Possession, between Kenai River and the lower end of Tustumena Lake, and in a few other places. The variations having the shallow and the medium-deep soils were found in all parts of the Kenai lowland visited, but there are extensive tracts where the one or the other is largely predominant. For example, very little shallow Knik loam was found between the big southerly bend of Kenai River and Tustumena Lake, the medium deep soil occurring here in almost solid tracts 3 to 4 miles across, interrupted only by small bodies of the shallow and deep phases and by a few narrow strips of Muskeg. The greater part of the beach land fronting on Cook Inlet from Homer Spit to Point Possession consists of a moderately deep loam, although there is much fine sand in the surface soil over a considerable part of a strip occurring immediately along the bluffs, some of this consisting of Knik fine sandy loam and very fine sandy loam. On most of the low, flat benches along the streams, such as Kenai and Kasilof Rivers and about Kenai, Skilak, and Tustumena Lakes, the shallow phase predominates, and associated with this are some quite sandy areas.

A notable development of the shallow phase of the Kenai loam is that on the Knik Arm lowland on the east side of the Government railroad from Campbell Creek to Eklutna River. On the high benches, such as those between Skilak Lake and the northern end of Tustumena Lake, both the shallow and medium-deep variations are found up to an altitude as high as 2,500 feet above sea level. Here the soil is generally dark brown in color, and the subsoil brown or greenish brown, and there are many large gravel and cobblestones in the lower part. There is also considerable of the black loam—the Chickaloon loam—associated with the Knik soils on the higher benches.

The Knik loam occupies flat and undulating bench lands, ridges, hillocks, and well-drained depressions, such as those in the hillocky areas. The soil occurs frequently on the steep slopes of hills and on the escarpments between benches, but such areas are not extensive. There are some sections in which the land has a choppy surface, characterized by irregularly distributed low hills or hillocks with numerous depressions which give rise to a type of topography unfavorable to cultivation. Many of these depressions are like potholes and probably are the result of unevenly melting ice beneath the glacial outwash material after its deposition.

In the main the soil is topographically well suited to cultivation; even the steeper slopes can usually be plowed safely, since erosion is not likely to be a serious problem on land of this kind by reason of its great absorptive capacity. (Pl. XVI, fig. 2.) As a rule, the smoother areas are those on the lower benches near Cook Inlet, around the lakes, and along the streams. Over the interior part of

the Kenai lowland—that next to the mountain slopes on the higher benches—the surface does not average so smooth, in the country seen, as that nearer the inlet. The most favorably situated part of the type for farming is that lying below an elevation of about 1,000 feet, owing chiefly to accessibility and the more favorable climate.

The drainage in general is good and inclined to be excessive in case of those bodies having a shallow soil. Satisfactory underdrainage is assured by the underlying gravelly stratum, so that where the seepage from adjacent slopes is not large the land is well drained, except in a few very low-lying flats and depressions without adequate drainage outlets. Even these areas are rarely so moist as to prevent the growing of crops. The soil also holds moisture well, except where the loose gravel comes near the surface; and probably crops would not suffer seriously in such situations if the soil were kept properly supplied with humus. The permeable nature of this mellow soil, so favorable to good drainage, is also favorable to good internal circulation of air.

It is on this type of soil that the most extensive forests of spruce and birch are found. The larger trees are on the deeper soil; white spruce attains a diameter upward of 24 to 26 inches and birch up to about 18 or 20 inches. Some medium to large-sized aspen and large cottonwood trees are found locally in these spruce-birch forests. Associated with these trees is usually an undergrowth in which high-bush cranberry, currant, buckbrush, devil's club, wild rose, huckleberry, alder, and willow are very common. In places this undergrowth attains tropical density and luxuriance. (Pl. XVII.) Other common plants in the woods are sphagnum moss, bunchberry, joint grass, redtop, low-bush cranberry, and fern. In the open places or natural glades through the forest the growth of redtop is dense and rank (Pl. XVIII, fig. 1), and frequently associated with this are fireweed, wild celery, redberry elder, and tall lupin. In the burned-over areas fireweed, Hudson Bay tea, sphagnum moss, moss berry, low-bush cranberry, wild rose, small willow, aspen, and lupin are abundant. In places bunch grass is found in these open situations, especially at the higher elevations. The shallow phase of this type has a characteristic growth of black spruce, much sphagnum moss, Hudson Bay tea, and low-bush cranberry. The black spruce trees are mostly less than 6 inches in diameter, and the flats over which they occur as practically an exclusive growth are locally known as "G pole flats." Aspen is also abundant in many places on the shallow soil, occurring often over extensive tracts with but a light intersprinkling of birch and spruce.

The medium deep and deep phases of the Knik loam represent the most valuable land of the region for farming purposes. It is upon

this soil that the ranchers of Matanuska Valley have attained such good results with potatoes, turnips, cabbage, and other vegetables, oats, and barley. The physical composition is the best, from the standpoint of crop production, of all the soils of this region. The soil is easy to clear and to plow. Most of the trees fall and turn up their roots when the land is burned over in spring. It is troublesome, of course, to pile the trees and branches for burning, still the land can be cleared with comparative ease because of the shallow root systems of the trees—much easier than most lands in the United States. Large areas were seen on the Kenai lowlands where practically all of the timber had been destroyed by fires, including roots, branches, and trunks, leaving the land so clear that in many places it was ready for the plow without any clearing whatever. Generally, however, in these burns the trunks of the trees have not been destroyed, though as often as not they have reached an advanced stage of decay and can easily be broken or cut and piled for burning. (Pl. XVIII, fig. 2.) There are usually present, also, saplings of aspen and birch and some small willows that require some labor in removal. In burning over the land it will not be necessary to burn the merchantable logs, as the first fire only causes the trees to fall. The soil is so mellow that a single horse and moderately light plow are effective, though a two-horse heavy turning plow or disk plow would be preferable in the preliminary breaking of the land, especially where there are many roots, small stumps, and bushes to turn up.

On Kenai Peninsula this land is used only in a small way about the villages and on the few homesteads that have been taken up along Cook Inlet. It has been used in small fields for potatoes, cabbage (Pl. XIX, fig. 1), turnips, and other vegetables, and to some extent for the production of oat hay for cattle. The vegetables are grown for home use. Some cattle and a few hogs and chickens have been raised on it at Kenai and Ninilchik and by several homesteaders elsewhere on the peninsula. It was on this soil that the live-stock station of the Alaska Agricultural Experiment Station was maintained at Kenai for several years, the station having been closed in 1908 and the live stock transferred to a new station on Kodiak Island. A small herd was maintained at Kenai exclusively on native pasture and the feed produced at the station. Success was had with raising cattle and with the making of butter and cheese. Oats, potatoes, peas, celery, lettuce, parsley, beets, carrots, mustard, cabbage, Brussels sprouts, broccoli, onions, and rhubarb, and several grasses were grown at this station. Good results were attained with oats for hay.

The following excerpts from reports[1] of the director of the experiment station give some of the results attending the work here:

In winter their [the cattle at the Kenai station] feed consists almost wholly of oat hay. This plant is chosen for its quick growth, comparatively heavy yield, and its excellent feeding qualities. Since being supplied with hay-making machinery we have been successful in putting the hay up in excellent condition, and it has remained bright and clean when stored away in the hay sheds. The oats are cut while in the milk stage, at which time they are best for hay. Oat hay is a palatable feed, greedily eaten by all stock, and is neither constipating nor unduly laxative. It is not a perfectly balanced ration and, of course, lacks in succulence, but as a single feed it surpasses any other produced in this latitude.

The Extra Early Ohio potatoes have done best here in yield, size, and quality. Larger and better potatoes were secured from raised beds than on level ground fertilized with stable manure.

Big Burton, Hanson, and Golden Stonehead (lettuce) were sown in the hotbed April 26 and not transplanted. All varieties produced immensely. This plant may be repeatedly cropped and will continue to send up a liberal supply of crisp, tender leaves throughout the season.

Celery seeded in hotbed April 26 and not transplanted was blanched nicely by placing boards along each side and throwing earth against them, and was of good size and quality.

Early Flat Dutch and Early Jersey Wakefield cabbage, sown in hotbed April 26 and transplanted to open ground May 29, produced solid heads of good quality.

Parsley and rhubarb did well.

Matanuska Valley ranchers say they produce from 300 to 400 bushels of potatoes per acre on the deep phase of the Knik loam without fertilization. (Pl. XIX, fig. 2.) They also obtain excellent results with turnips, particularly the Petrowski, and with radishes, cabbage, rhubarb, and lettuce.

Barley of a beardless variety has been repeatedly matured on the Knik loam near Knik, and early oats have also been matured. Garden peas produce very tall vines and fruit heavily. (Pl. XX, fig. 1.) Canada field peas also do well. White clover thrives in volunteer patches. Among other crops grown to some extent are carrots, parsnips, kale, kohl-rabi, spinach, cauliflower, buckwheat, flax, timothy, and rye. Many different kinds of flowers are grown in yards. Some of the more common are the nasturtium, poppy, sweet-pea, pansy, daisy, and sweet alyssum.

Native redtop grows luxuriantly in many places and is the grass principally used in making hay. It reaches a height of 6 feet or more in open places and is often abundant in the woods. Large areas of it are found on the higher benches and mountain slopes, extending above timber line. It was not plentiful in the big burns

[1] Annual Report Alaska Agr. Expt. Sta., 1907, p. 63. Annual Report Alaska Agr. Expt. Sta., 1906, p. 50.

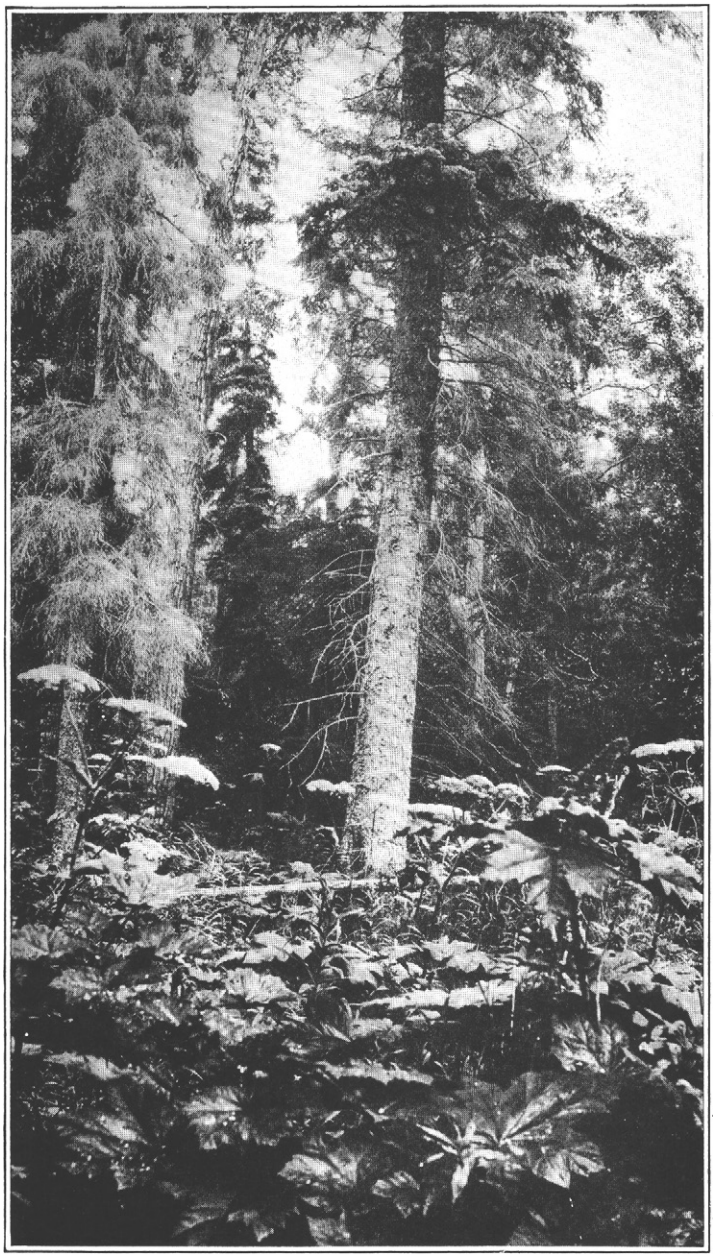
between Skilak and Tustumena Lakes, but was seen in abundance in some of the burns crossed elsewhere.

Wherever wood ashes and stable manure have been used on this soil, an increase in yields has resulted. The very acid nature of the soil indicates that applications of lime would be helpful, as such marked acidity generally indicates an unfavorable soil condition for most plants. This is shown by the better growth of plants in those places where brush heaps have been burned. The soil seems to improve with cultivation, at least better crops are obtained after two or three years of cultivation. Undoubtedly the better aeration induced by cultivation contributes to this improvement. Although the Knik loam naturally contains a good supply of organic matter, it is possible that continuous cultivation will after a time necessitate the growing of crops like vetch, clover, Canada peas, or the native beach pea (*Lathyrus maritimus*) to maintain this valuable soil constituent. In this respect the use of kelp as fertilizer would also be advisable.

In the report of 1914[1] the following statements concerning this soil were made:

> The Knik loam is the soil which will play the most important part in the building up of an extensive agriculture in the Cook Inlet-Susitna region. It is the best farming soil of the region and at the same time is the most extensive type and the most accessible. There are no large sections in which the type does not occur. In the main it lends itself to easy cultivation, owing to its favorable physical character and smooth topography. It is not a difficult task to clear this land, because of the shallow depths to which the roots of trees penetrate, coupled with the fact that burning over, during dry seasons, clears away the bulk of the undergrowth. The soil is so well supplied with organic matter that burning over will not likely effect any material damage; in fact, the ashes thus produced have been found to have a decidedly beneficial effect on the soil. Coarse organic matter plowed under in too liberal quantity is not helpful to the land, owing to the slowness of decomposition processes in this climate. The type is everywhere decidedly acid. It is much in need of lime, as indicated by the good effects resulting from applications of wood ashes. Lime-requirement determinations of samples of the virgin soil showed the amount required to correct acidity in an acre-foot to be very large. Sample No. 590120 required 6.2 tons of calcium carbonate to correct acidity of an acre-foot, while sample No. 590121 (subsurface of No. 590120) required 10.9 tons of calcium carbonate to neutralize a corresponding section of that material. In practice not so heavy applications will be necessary, since the lime of ashes resulting from burning over the land will have considerable effect, while oxidation of organic matter in the soil resulting from better aeration consequent upon cultivation will further minimize acidity, according to experience, and thus reduce the quantity of lime needed. Experience also shows that the condition of the soil improves with cultivation, which fact undoubtedly has some connection with the improvement of the acid condition of the virgin

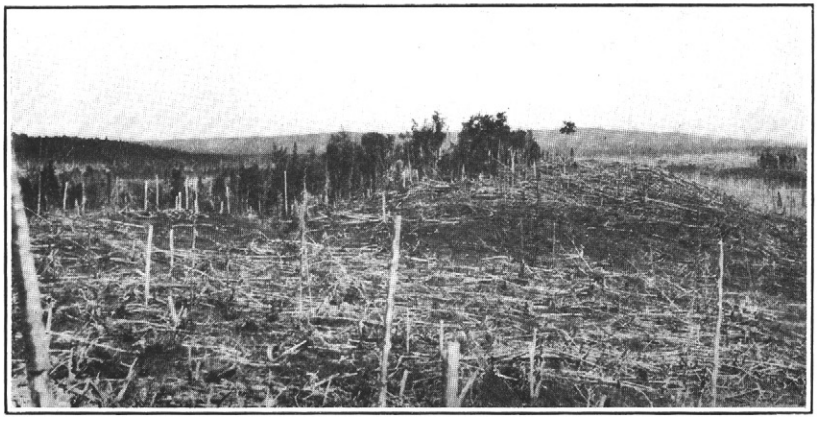
[1] Soil Reconnoissance in Alaska, Field Operations of the Bureau of Soils, 1914, p. 47.



CHARACTERISTIC SPRUCE FOREST AND DENSE UNDERGROWTH ON KNIK LOAM, KENAI LOWLANDS.

FIG. 1.—A GRASSY GLADE ON DEEP KNIK LOAM, KENAI LOWLANDS.

There is a good stand of grass here, but it is young and short.



S8726

FIG. 2.—DESTRUCTION OF SPRUCE FOREST BY FIRE.

In this burn, about 6 miles above the mouth of Kasilof River, the trees felled by the fire are rapidly decaying and could be piled and burned without much labor.

S8737

FIG. 1.—YOUNG CABBAGE ON MEDIUM-DEEP KNIK LOAM, ANCHORAGE.

S8788

FIG. 2.—YOUNG POTATOES ON DEEP KNIK LOAM, NEAR MATANUSKA JUNCTION.

S8748

FIG. 1.—GARDEN PEAS IN GARDEN AT ANCHORAGE ON MEDIUM-DEEP KNIK LOAM.

S8758

FIG. 2.—GRAIN ON SHALLOW TO MEDIUM-DEEP KNIK LOAM, 6 MILES ABOVE ANCHORAGE ON SHIP CREEK.

soil or that unfavorable condition typified by acidity, through processes of weathering made possible by breaking the land. Furthermore, the estimate for lime requirement is for an acre of soil 1 foot deep, when it is practically certain that not so deep a section should be considered in the actual field practice of liming. Nevertheless, a soil so acid can not but be benefited by lime and it is certain that liberal applications could be made to advantage. Two tons of air-slaked burned lime per acre in all probability would not be too much, yet lighter applications likely would have some beneficial results.

The shallow phase of this type, the "G pole flats," gives poorer results than the deeper soil, especially in dry years. Crops tend to suffer on it as a result of too thorough drainage in dry seasons. When the shallow soil is manured, however, good yields are obtained, at least in years of sufficient rainfall. This shallow soil seems best suited to the production of vegetables, although some oats are grown. (Pl. XX, fig. 2.)

Of the 2,750 square miles comprised in the Kenai lowland, probably 1,000 square miles consists of Knik loam. This represents one of the largest bodies of possible farming land in the southeastern Alaska coast country.

The following table gives the results of mechanical analyses of the soil, subsurface, and subsoil of the soil of loam texture and also that of silt loam texture. Similar analyses of the Knik silt loam, deep phase, as developed in the Matanuska Valley, are given for comparison.

Mechanical analyses of Knik loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
	TYPICAL SOIL.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
590229	3½ miles northeast of Anchorage, east side Knik Arm.	Soil, brown loam, 0 to 18 inches.	0.6	1.6	2.2	13.2	20.5	49.7	12.5
590230	.....do.....	Subsoil, greenish-brown fine sandy loam, 18 to 36 inches.	.1	.4	.9	29.5	29.6	33.4	6.3
590246	Mouth of Cottonwood Creek on Skilak Lake, Kenai Peninsula.	Soil, yellowish-brown loam, 2 to 16 inches.	2.0	6.9	5.6	12.4	11.3	48.2	13.7
590249	About 4 miles out on trail leading from mouth of Kings county Creek, Kenai Peninsula.	Soil, brown loam, 0 to 8 inches.	.1	1.0	1.2	18.6	18.4	47.6	13.4
590250	.....do.....	Subsoil, yellowish-brown fine sandy loam, 8 to 18 inches.	.4	3.4	4.8	38.2	19.2	27.1	6.9
590253	Quartz Creek delta on Kenai Lake, Kenai Peninsula.	Surface soil, light gray silt loam, 1 to 3 inches.	4.9	12.8	2.5	7.4	9.5	52.8	10.2
590254	.....do.....	Subsurface, yellow loam to coarse sandy loam, 3 to 6 inches.	24.4	35.0	5.0	5.0	2.2	16.8	11.8
590255	.....do.....	Subsoil, greenish-brown gravel, 6 to 20 inches.	26.0	53.6	10.8	5.6	0.6	1.0	2.2

Mechanical analyses of Knik loam, deep phase.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
	DEEP PHASE.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
590256	On bench just south of Ninilchik, Kenai Peninsula.	Soil, nearly black to brownish loam, 0 to 8 inches.	0.1	3.0	5.4	14.6	18.6	43.2	15.0
590257	.....do.....	Subsoil, yellowish-brown loam, 8 to 36 inches.	.0	2.4	3.2	20.2	21.0	41.2	12.4
590224	One-half mile above Matanuska Junction, Matanuska Valley.	Soil, silt loam, 0 to 5 inches.	.1	.4	.3	2.8	22.8	66.6	7.0
590225	.....do.....	Subsurface, yellowish-brown silt loam, 5 to 36 inches.	.2	.9	1.0	7.6	20.7	60.2	9.5
590226	.....do.....	Subsoil, yellowish-brown fine sandy loam, 36 to 40 inches.	2.4	5.2	3.4	22.4	24.5	35.2	7.2

Mechanical analyses of Knik silt loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
	TYPICAL.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
590205	2½ miles above mouth of Anchor River, on Cook Inlet, Kenai Peninsula.	Soil, brown silt loam, 0 to 12 inches.	0.0	0.6	1.0	11.0	17.8	51.8	17.9
590206	.....do.....	Subsoil, brown fine sandy loam, 12 inches.	.0	.4	.8	23.6	26.0	40.6	8.6
590219	1 mile above Horne's cabin on Chickaloon River, Kenai Peninsula.	Soil, yellowish-brown silt loam, 0 to 8 inches.	.4	4.5	4.0	15.8	7.4	53.5	14.3
590220	Burnt Island, Kenai Peninsula.	Soil, coffee-brown silt loam, 0 to 16 inches.	1.0	1.0	1.0	10.0	7.6	59.8	19.9
590221	.....do.....	Subsurface, greenish-yellow silt loam, 16 to 26 inches.	.2	.8	.6	2.9	8.4	77.2	9.8
590222	.....do.....	Subsoil, grayish silt loam, 26 to 36 inches.	1.0	2.4	1.3	5.8	11.4	68.4	9.4
590223	On west side bench near confluence of Chickaloon River and East Fork Chickaloon River, Kenai Peninsula.	Soil, yellowish-brown silt loam, 0 to 14 inches.	1.4	3.6	3.4	18.0	9.4	52.6	11.6
590233	Experiment station pasture at Kenai, Kenai Peninsula.	Soil, brown silt loam, 0 to 10 inches.	.4	2.2	2.8	10.6	15.0	51.6	17.6
590234	.....do.....	Subsurface, greenish-brown silt loam, 10 to 20 inches.	.1	.6	.9	3.8	23.6	63.3	7.9
590235	.....do.....	Subsoil, greenish-brown fine sandy loam, 20 to 36 inches.	1.0	6.8	8.2	34.0	22.5	23.6	3.8
590247	5 miles northeast of lower end of Tustumena Lake, Kenai Peninsula.	Soil, brown silt loam, 0 to 15 inches.	.1	.6	1.4	14.9	18.2	56.3	8.8
590248	.....do.....	Subsurface, pale yellow to light olive silt loam, 15 to 26 inches.	.1	.6	.8	7.6	26.7	58.7	5.3

KENAI LOAM.

Small bodies of soil consisting of a brown loam or silt loam underlain at about 5 to 15 inches by pale-olive to grayish compact silt loam or silty clay loam were encountered in a number of places in the Kenai lowlands. Usually greenish-brown colored gravelly material like that in the subsoil of the Knik soils is reached within the 3-foot

section. This soil was found in the hillocky country and in that having a choppy surface configuration. It occurs in very intimate association with the Knik loam. It was not seen in areas of more than a few acres extent, and, therefore, appears to be a soil of little importance. More of it was seen on the east side of Chickaloon River above the fork than anywhere else. The compact subsoil may influence the behavior of soil moisture; it may have the effect, particularly when occurring near the surface, of making this a cold-natured, late soil. But for the gravelly material beneath, level bodies of it probably would have imperfect drainage. With the characteristic uneven surface the drainage is good. Where the soil is a foot deep probably about the same results would be had as on the Knik loam, but on the shallow areas it is believed there would be some difference in the matter of maturity of crops in favor of the Knik loam.

CHICKALOON LOAM.

The Chickaloon loam represents imperfectly drained Knik loam with a black mucky surface soil. This kind of land is found in depressions or flats and on the higher benches and on slopes where there is considerable seepage water. No large bodies of it were seen. Several strips were crossed in some low flats, which probably would comprise 20 acres or more, and other narrow strips lie on the bench escarpments.

The typical soil is a black muck or mucky loam, underlain at about 10 to 24 inches by yellow, greenish-yellow, or greenish-brown loam to silt loam, and this, in turn, in the lower part of the 3-foot section or in the substratum by greenish-brown, gravelly material. There are frequent depressions in the low flats containing water, associated with mossy hummocks on which vegetation is established. Some of these low, flat areas occur as strips along streams. The flats apparently are wet because of imperfect drainage outlets, although seepage may have considerable to do with the poor drainage. The areas on slopes are kept wet by seepage. Considerable peaty material occurs in places in the areas of this soil. The flats can be drained by ditching, and some of the slope strips also probably could be drained by ditches to intercept the seepage flow.

This soil supports some large trees of both spruce and birch, much good native redtop, alder, willow, devil's club, high-bush cranberry, and wild celery. If drained, it probably could be used for celery. The black mucky surface soil is like the muck land which in many parts of the United States is used with the best results for this crop. Some drained patches have been used in this region for turnips, potatoes, cabbage, beets, and other crops. Cabbage and turnips appear to give best returns. Additions of lime and manure and

probably also of kelp may be expected to increase the yields. The higher areas, including some above timber line, are most valuable for the grass that flourishes on them.

KACHEMAK VERY FINE SANDY LOAM.

The Kachemak very fine sandy loam is a brown, very fine sandy loam, passing at depths of 10 or 12 inches into yellowish-brown very fine sandy loam. The immediate surface soil is high in organic matter and when dry is very friable or fluffy. The surface soil to a depth of about 3 to 6 inches has a dark-brown to black color, owing to its high content of decaying vegetable matter. There is little textural change from the surface down through the subsoil and into the deep substratum. On the slopes of the high benches along Swift and Fox Creeks there are deep bare exposures of this material which through depths of 100 feet or more show the characteristics of the subsoil described above. As a matter of fact, there are very steep slopes here where there is very little variation in the material through a range of elevations from less than 100 feet above sea level to more than 1,000 feet, aside from the presence of coal beds (lignite) at different levels. At some levels there is more silt present and the color is grayer, and it seems reasonable to assume that much of the high bench land of the Caribou Hills country south of Fox River and between Kachemak Bay and Tustumena Lake is underlain by the same kind of deposits.

The uniform texture and structure of the material through the deep vertical section and the absence of gravel suggest that the deposit may represent wind-blown material. It is much like some of the wind-blown sandy soils occurring in the uplands near streams in the central part of the United States (Knox soils), and is also similar to the Fairbanks soils [1] along the slopes of the Tanana River of the interior of Alaska, which also appear to be of wind-blown origin. But the evidence at hand, it must be said, is not conclusive as to the origin of the material of this soil.

This soil was seen at elevations reaching 1,200 feet on the north side of Kachemak Bay. On the higher levels the surface is flat to undulating. Streams have cut back into it, forming deep canyons with very steep to almost vertical walls. Similar steep slopes also face Kachemak Bay. Some of the slopes have a well-developed steplike character, resulting from the more resistant nature of the coal seams, which withstand erosion and act as a support to the succession of benches.

[1] See Soil Reconnoissance in Alaska, Field Operations of the Bureau of Soils, U. S. Dept. of Agriculture, pp. 145–150.

The smooth highland levels in this country are dotted with clumps of rather small spruce, the intervening open ground being occupied by redtop and bunch grass, with here and there a clump of alder and willow. There are other grasses, including bluegrass and fescue (*Festuca ruba lanuginosa*), and an abundance of wild celery, bluebell, lupin, some small goldenrod, and a variety of other flowers. The steeper flanking slopes are generally bare, and from these clouds of dust are blown up in dry weather. Occasionally sheets of the surficial material upon which the vegetation has established itself break loose and slide down the steep slopes.

There is an abundance of redtop on the smoother slopes and bench situations. Here the grass grows very dense and much of it to a height of 6 to 9 feet. The amount of grass that annually goes to waste on these slopes is enormous. Some fireweed, mountain ash or red elderberry, and a vetchlike vine grow with the redtop, and alder is present in many places on the slopes.

From the country seen and the reports of those familiar with this part of Kenai Peninsula there is a very large area of this land in the smooth highlands of the Caribou Hills. (Pl. XXI, fig. 1.) Most of it lies at elevations between 1,000 and 3,000 feet. This elevation may be too great for best results with crops, although it may be possible to grow grain hay and root crops to advantage, if stock raising should become important here. The best use of this land in an agricultural way likely would be for grazing cattle. On this soil along Kachemak Bay was the best area of natural grass seen by the writer in Alaska. Not only is a large part of the slopes and smooth upland heavily grassed, but also the adjacent benches skirting Kachemak Bay and the stream bottoms.

A homesteader near the mouth of Fox Creek puts up enough hay for his horse from a small patch on the lower slopes of this soil. In this place he reports having cut 2½ to 3 tons of hay per acre in 1916, the third successive year of cutting. It is believed that much of the slope land would cut 4 tons of redtop hay per acre.

There are several garden patches on the smooth slopes of this soil in which potatoes, cabbage, kale, turnips, radishes, lettuce, and other vegetables are grown. One homesteader states that the soil is so rich that crops are inclined to make too rank a growth.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Kachemak very fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm	Clay, 0.005 to 0 mm.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
590209	Three-fourths mile above mouth of Swift Creek, Kenai Peninsula.	Soil, light-brown very fine sandy loam, 0 to 36 inches.	0.2	0.6	0.8	21.7	35.0	33.6	8.2
590238	1 mile above mouth of Swift Creek, Kenai Peninsula.	Soil, brown very fine sandy loam to very fine sand, 0 to 12 inches.	.1	.6	1.0	15.6	33.1	35.6	14.1
590239	.....do.....	Subsoil, yellowish-brown very fine sandy loam, 12 to 36 inches.	.1	.2	.6	15.2	37.2	37.0	9.7

TALKEETNA LOAM.

The Talkeetna loam represents the mountain-slope soil of the Cook Inlet region. It is found on Kenai Peninsula up to elevations of approximately 4,000 feet above sea level, with probably some thin patches on shelves and in notches between rocks even higher than this. It ranges in depth from 3 feet or more on some of the lower slopes to a thin veneer barely covering the rocks of shelves and other situations capable of holding the soil in place against erosion. That above 3,000 feet is very thin and patchy in occurrence. The line of mergence between soil of the Knik character, with gravel in the subsoil, and the typical Talkeetna loam, which does not have gravel beneath, is not distinct, except where the Knik occupies high benches lying against the mountain slopes. Some areas of good Knik loam occur on rather steep slopes, as on the slope at Burnt Island on Chickaloon Bay.

Aside from the absence of the gravelly substratum, the Talkeetna loam is much like the Knik loam. It has in most places, where there is a covering of vegetation, a thin grayish surface layer like that of the Knik soils, and under this a brown to dark-brown subsurface stratum which passes beneath into lighter brown loam. On the lower slopes there is some spruce and birch, but most of the soil is above the timber line. The lower part of that above timber line supports much redtop and dense thickets of alder and scrub spruce; above this there is heather growth, consisting of dwarf birch, willow, blueberry, Hudson Bay tea, and sphagnum moss. This vegetation thins out with ascent of slope, the shallow soil of the high areas supporting

scattering small blueberry bushes and reindeer moss. Many flowering plants, including aster, goldenrod, violet, and others, grow on this soil. There are also some species of grasses that flourish on the upper slopes, including species known as "wild timothy."

The only value this land has, at least the greater part of it, is for pasture. Mountain sheep and goats get their pasturage here, and moose graze here at certain seasons. Much valuable pasturage could be had here for cattle. At Kodiak, on Kodiak Island, cattle were seen grazing on similar lower mountain slopes.

The following table gives the results of mechanical analysis of a typical sample of the soil of the Talkeetna loam:

Mechanical analysis of Talkeetna loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay 0.005 to 0 mm.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
590245	Near forks Benjamin Creek and Killey River, north side, Kenai Peninsula.	Soil, brown loam, 0 to 3 inches.	9.7	8.8	2.8	7.9	11.7	49.6	9.8

MUSKEG.

Muskeg, as typically developed, consists of treeless peat bogs; that is, marshy bodies of peat. In this report the term is employed in a broader sense to include a timbered phase of peat which is shallower, whose surface is a little higher and whose drainage is slightly better than is the case in the typical treeless Muskeg. Locally Muskeg is called not only Muskeg, but indiscriminately tundra and swamp. It is distinctly different, however, from the tundra of northern Alaska, which is not necessarily marshy and which frequently has an uneven surface. It also differs from swamp. Swamp is the term ordinarily used to designate the overflowed, timbered stream bottoms and very poorly drained timbered flat country, such as the swamp lands of the lower Mississippi River bottoms and of the Dismal Swamp of Virginia and North Carolina. Muskeg is much like the treeless areas of peat found in the Everglades of Florida and other peat bogs. The terms "bog," "marsh," or "morass" could properly be used to designate the treeless Muskeg.

Muskeg occurs as relatively low, level areas of very irregular outline, surrounded or partly surrounded by higher, well-drained, timbered land, and often including isolated low hummocks, hillocks, and ridges of similar land. The drainage is poor because of the level surface, low position, and inadequate outlets. Some bodies are com-

pletely inclosed by high land, but in some of them streams have their heads. The smaller areas have the appearance of filled-in lakes, and, in fact, this is what the Muskeg, much of it at least, represents—former lakes that have been filled with the remains of vegetation encroaching from their sides. The numerous lakes that now occur through these bogs will probably disappear in time if the present drainage features are not artificially changed.

The material of the typical treeless bogs consists of brown fibrous peat composed largely of sphagnum moss, but including also the remains of the grasses, shrubs, and other plants that grow about the edge of the water. Nearly everywhere the surface is covered with sphagnum moss, and there are many places where greenish-yellow moss with the original structure perfectly preserved is found at depths of 2 and even 3 feet. The cool climate probably has much to do with this slight alteration of the moss at such depths.[1] Much of the material is partly decayed, however, and has a felty or pulpy consistency. Frequently the material at the immediate surface, where there is not much living moss, is finely disintegrated and has a dark-brown or black color.

In addition to moss, the areas of Muskeg support a heather growth composed of dwarf birch (seldom more than a foot or two in height), wild sage, Hudson Bay tea, blueberry, squaw berry, moss berry, and an occasional dwarf black spruce. The vegetation on Muskeg has a hummocky character, growing in bunches or tussocks, with frequent small shallow pools of water in the intervening depressions. Around the lakes the heather generally grows as a narrow, marginal strip, standing as a miniature ridge a few inches above the general level of the bog farther back from the water. Slough grass (*Carex*), native redtop, and various flowers grow scatteringly on the treeless areas. In places where there are shallow pools of water throughout summer slough grass is abundant. A water lily with yellow flowers is plentiful in the lakes.

In winter the bogs are frozen over and offer splendid footing for travel with dog sleds, but in summer travel is extremely tiresome. Unless one steps on the tussocks or hummocks offering more substantial footing on account of the turf-bound condition, the foot sinks deep with each step into the saturated moss and spongy peat.

Travel with horses through such marsh land would be very difficult or impossible in summer. The depth of the peat averages considerably more than 40 inches.[2]

[1] On Aug. 31, 1916, ice was found at depths ranging between 20 and 30 inches below the surface just north of the confluence of Killey and Kenai Rivers.

[2] The auger used in making soil borings was 40 inches long, and with this no fine mineral soil material or gravel could be reached, but gravel and cobblestones were seen in the bottoms of some of the shallow lakes of the Muskeg areas, indicating the presence of such material in the strata underlying the bogs.

The timbered phase of Muskeg represents those areas where the peat is generally not more than 20 to 36 inches deep over soil material like that of the poorly drained areas of Knik loam. Here the surface stands a few inches or a foot or more above adjacent areas of treeless Muskeg, and the drainage is better but not perfect. The peat here is composed very largely of the remains of moss, and everywhere deep, spongy sphagnum moss occupies the surface. The trees are small black spruce seldom over 4 to 6 inches in diameter. They often grow so thick that they must be pushed aside for one to get through them. An occasional small willow, birch, or alder is found in the spruce. Ice was frequently found in this moss peat in late summer at depths of less than 3 feet.

Timbered Muskeg occurs in generally flat areas, but the surface in detail is faintly undulating or hummocky. It forms low flats not many feet above the beds of streams, as, for example, along Benjamin Creek near its confluence with Killey River, and over similar flats from near sea level to the highest benches, such as those on the north side of Big Indian Creek, above the first forks. Not being so wet and marshy it might be well in a more detailed survey of the soils to separate material of this kind as timbered peat.

Flats of marshy muck material occur in association with the Muskeg, though usually not in large bodies. The material here consists of black vegetable remains much more thoroughly decayed than the material of the Muskeg, and frequently containing some soil material which has been mixed with the vegetable matter by the upturning of tree roots or by running water. The organic material is ordinarily 16 to 30 inches deep, and beneath this is found brownish, bluish, and greenish soil material, varying in texture from sand to loam and having the characteristics of the Knik on the benches and of the Susitna soils in the bottoms. White spruce and birch are common on this phase, some trees having a diameter of 20 inches or more in case of the spruce and 16 inches in case of the birch. Sphagnum moss, alder, willow, and black spruce are also abundant. Redtop, jointweed, and other plants are plentiful in many places. This material really is more closely related to muck than to the typical Muskeg. It is related to Muskeg through the abundance of moss, its low, flat position, and poorly drained, marshy condition. In a detail soil map it probably would be classed as Muck.

Muskeg is of wide occurrence through the Knik lowlands. It is more abundant near the shores of Cook Inlet than farther back toward the mountains, as judged by the country seen and the statements of trappers and others who have traveled here. It is more extensive than the Knik loam over a wide strip along the lower Kenai River, and is said to predominate in a belt back from and paralleling the timbered strip immediately along Cook Inlet, ex-

tending from the vicinity of lower Kenai River northward to the vicinity of Chickaloon Bay. There are also important areas in the corresponding portion of the lowlands, southward from the lower Kenai. In a number of places Muskeg comes out to the shore line along Cook Inlet, especially north of Kenai. The Muskeg does not, however, occur anywhere in vast, uninterrupted bodies, though one could travel over Muskeg for a distance of 12 miles or more back from the village of Kenai, it is said, by winding between the frequent hillocks and ridges associated with the bogs. Many of these ridges and hillocks are islandlike, completely surrounded by the Muskeg.

While much less extensive over the interior portion of the lowlands, small and occasional large bodies of Muskeg occur here and there back to the foot of the high benches lying against the Kenai Mountains; but in the country traveled through during the progress of this reconnoissance the well-drained Knik soil was found to be much more extensive than the Muskeg. On the basis of the information obtained, it appears that considerably less than half of the Kenai lowland is occupied by Muskeg. Probably one-fourth or more of this consists of the timbered phase. But these estimates are rough, and until the country is surveyed in much more detail the exact extent and distribution of the Muskeg can not be ascertained.

This bog land has little present value for agriculture. It supports some grass that might at times be used for pasturage, if the raising of cattle becomes very important here. But even for pasture land it is not particularly promising. It not only possesses little or no present value, but serves to make areas of well-drained land inaccessible. Roads could be built through the bogs, it is true, but these would be expensive, especially where the peat deposit is deep.

Natives of Finland now living on Kenai Peninsula told the writer that the same kind of peat bogs were utilized in Finland for growing rye, by first draining with canals and ditches and then by lightly burning over the surface, in dry seasons, at intervals of one or more years.

The timbered phase of Muskeg might be used to some extent if the moss could be burned off. Stripping off the moss would be very expensive, and without ditching the drainage might not be thorough enough to allow cultivation.

To sum up, the areas of Muskeg represent very unattractive land from the standpoint of immediate farm use.

SUSITNA FINE SAND.

The Susitna fine sand consists of brownish-gray to bluish-gray fine sand, passing into bluish or greenish-brown fine sand, and underlain

anywhere between 6 inches and 3 feet by gravel and sand, and in places cobblestones. It is closely associated with patches of gravelly sand, and usually is found only in small bodies in the low bottoms subject to rather frequent overflow. On account of its open nature, it does not hold moisture well, and unless well supplied with manure it probably would give low yields, especially in dry seasons. It usually does not support a heavy growth of spruce and birch, but cottonwood thrives on it. Alders also are very plentiful.

SUSITNA FINE SANDY LOAM.

The Susitna fine sandy loam is a brown to brownish-gray fine sand or loamy fine sand passing beneath into bluish or greenish-brown fine sandy loam to silty clay loam, which, in turn, usually passes within the 3-foot section into a mixture of sand and gravel. In many places, especially near glaciers, there are frequent low hummocks of mixed sand, gravel, and cobblestones through the fine sandy loam, and such material is commonly present within a few inches to a foot or so of the surface. This is notably true along the stream bottoms crossed by the Government railroad between Kenai Lake and Turnagain Arm.

On the broader flats there is often present a surface covering of dark-colored material containing much decaying vegetable matter, and beneath this there is present in places a thin gray layer like that found beneath the vegetable mold covering the Knik soils.

This soil occurs both as low bottoms subject to overflow and as higher bottoms that are no longer flooded as they were before the streams had cut down their channels to the present levels. In other words, some of the soil occurs as low second bottoms. Sometimes ice jams may cause local overflow of the higher bottoms. Some low bottoms are not subject to overflow, apparently because the streams do not carry as much water as formerly, when they were fed by glaciers since melted or removed beyond the headwaters of the streams.

The drainage is well established, except in some places in the lowest bottoms and in places where drainage outlets have been obstructed. Generally the surface is level, but there are mounds, swells, and swales that frequently influence the local drainage conditions.

This soil is of common occurrence along most of the streams of Kenai Peninsula. There is much of it on the broader flats of the glacial streams and on the concave side of the bends of the creeks and rivers. It is very much less extensive than the Knik loam, but it is locally important, especially because it is accessible and easy to cultivate.

A large part of the type supports a heavy growth of white spruce, birch, and cottonwood. The largest cottonwoods grow on this and the other Susitna soils, many of the trees being 30 inches in diameter. Much of the spruce and birch is as large as that found anywhere on Kenai Peninsula. Around the head of Turnagain Arm and in the bottoms of the streams of the Kenai Mountains hemlock is plentiful. Some of these trees attain a diameter of 3 to 4 feet. Alder is abundant, especially where the stand of trees is not thick, as in some of the bottoms near glaciers. Willow also is locally plentiful. Red elderberry, devil's club, high-bush cranberry, redtop, bunch berry, joint grass, wild celery, currants, and ferns are some of the plants which in many places constitute a very dense undergrowth. There is considerable sphagnum moss, but it is not nearly so plentiful as on the bench lands.

This land can not be cleared so easily as the bench soils, for the reason that the vegetable mold remains moist longer than on the higher bench lands and fires do not so readily cause trees to fall. The trees also have a deeper root system, apparently, in the bottoms, and on this account do not fall so frequently as on the bench lands.

A number of garden patches were seen on this soil near the villages and about the cabins of homesteaders and trappers. The common vegetables grown in this country, such as potatoes, cabbage, turnips, rutabagas, radishes, and garden peas, do very well. Oats also do well, at least good yields of oat hay were made in the few very small patches seen. Potatoes probably will be too watery if grown in wet depressions, but this can be remedied readily by ditching the land. The native redtop gives good yields of hay, and some healthy volunteer bunches of timothy were seen. Vetch, white clover, and such legumes as the native wild peas, the beach pea in particular, very likely can be made successful forage and soil-improving crops on this type of soil.

Applications of barnyard manure and fish scrap have increased the yields. Kelp might also prove a valuable fertilizer for the soil. Applications of burnt lime would probably improve conditions considerably. While the soil does not seem in general to be so acid as the Knik soils, it is acid, at least in many places. Wood ashes increase the yields, indicating that lime or potash, probably both, are helpful to plant growth. The kelp plant contains potash, and there is no reason why it could not be used in any quantity desired; that is, where there are roads over which it can be hauled from the beaches to the farm. The same is true of lime and fish scrap.

Wild raspberries were seen in places on this soil. At Hope raspberries are grown with good results. Wild currants do well, and it is not unlikely that cultivated currants and gooseberries would succeed.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Susitna fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
590217	1 mile above mouth of Sunrise Creek, Kenai Peninsula.	Soil, brown fine sandy loam, 0 to 12 inches.	0.6	7.0	7.6	31.4	11.8	26.0	15.6
590218	.....do.....	Subsoil, bluish fine sand, 12 to 18 inches.	1.0	11.8	14.5	50.4	8.4	7.4	6.8

SUSITNA LOAM.

The Susitna loam is a brown to dark-brown loam grading at depths of about 10 to 15 inches into bluish loam or silty clay loam, with greenish-brown gravel and sand at about 15 to 30 inches.

This type is associated with the Susitna fine sandy loam, silt loam, and silty clay loam. It usually has a patchy occurrence, grading off into the other Susitna soils within short distances. It has about the same forest growth and drainage as the fine sandy loam, is adapted to the same crops, and will likely require about the same treatment. It may be expected to give better yields or prove more durable than the sandy type. At Hope, cabbage, cauliflower, potatoes, carrots, beets, rhubarb, lettuce, garden peas, kale, raspberries, rutabagas, kohl-rabi, and Swiss chard are successfully grown. At Hope, celery of crisp texture and good flavor is said to be grown on this soil, and string beans are said to fruit well on it.

The following table gives the results of mechanical analyses of the soil and subsoil of the Susitna loam:

Mechanical analyses of Susitna loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
590214	Hope, Kenai Peninsula	Soil, dark brown loam, 0 to 12 inches.	1.0	2.6	2.2	20.2	19.8	44.2	9.9
590215	.....do.....	Subsoil, bluish loam, 12 to 30 inches.	.2	1.2	1.3	16.6	18.7	49.0	12.7

SUSITNA SILT LOAM.

The Susitna silt loam is a brown to mottled brownish and bluish silt loam, underlain at about 3 to 5 inches by bluish silt loam, which grades beneath into bluish or greenish gravel and sand. It differs from the Susitna loam simply in its finer texture, and has the same patchy occurrence and intimate association with the other Susitna soils. It probably has very nearly the same agricultural value as the loam.

SUSITNA SILTY CLAY LOAM.

The soil of the Susitna silty clay loam is a brown to dark-brown silt loam to silty clay loam, which shows mottling with gray below the surface few inches, and changes to bluish silty clay loam mottled gray and brown at about 4 to 8 inches. The subsoil beginning at depths of 10 to 30 inches consists of bluish sand, fine sand, or loamy sand, frequently with layers of mottled bluish and rusty-brown fine sandy loam, silt loam, loam, or silty clay loam. Gravel is generally reached at 24 to 30 inches. In places gravel reaches nearly to the surface. There is often present a dark-colored surface layer rich in vegetable matter.

This soil was seen in several places in the bottoms of Kenai River and Salmon Creek. It has a patchy occurrence, being associated with the other Susitna soils. It has the same forest growth, and probably would be suited to about the same crops, although it is likely some crops such as potatoes and beans would not do so well as on the more friable and better drained types, on which crops may be expected to grow more rapidly. It is believed that this is a better grass soil than the lighter textured types. At mile 7, near the Government railroad out of Seward, timothy this year (1916) gave a yield of nearly a ton per acre on rough stump land, where the stand was not at all regular, owing to rough ground and imperfect distribution of seed.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Susitna silty clay loam:

Mechanical analyses of Susitna silty clay loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
590236	One-half mile above mouth of Swift Creek, Kenai Peninsula.	Soil, brown silty clay loam, 0 to 15 inches.	0.2	0.6	0.5	5.4	14.4	52.9	26.4
590237	.....do.....	Subsoil, brown clay loam, 15 to 36 inches.	.6	2.0	2.2	18.1	14.2	42.2	20.7

MUD FLATS.

In the bays of Cook Inlet and about the mouths of the large streams entering this body of water there are considerable areas of Mud flats or tide flats which have been built up of fine sediments brought down by the streams. The glacier streams bring down immense quantities of silt and fine sand in summer when the glaciers are most active and are giving off maximum quantities of water charged with fine sediments. This material, consisting largely of silt and very fine sand, is deposited in those places where the tides rush in against the silt-laden waters and where there is no strong ebb tide to sweep away the mud banks as they are formed. The most important of these flats are at the head of Turnagain Arm and Kachemak Bay and at the mouths of Chickaloon, Kenai, and Kasilof Rivers. There are other small flats at the mouths of many of the creeks, among them Resurrection, Sixmile, and Glacier Creeks. Turnagain Arm and Kachemak Bay appear to be filling up with this material. Those who have lived in these localities state that during the last decade the filling of Turnagain Arm from its head has gradually restricted the navigable water and even altered the behavior of the bore that rushes up this fiord at the head of flood tides.

Much of the flats is covered daily by tide water, but portions, such as the higher part of the Chickaloon flats, for example, are inundated only at times of the highest tides. In Turnagain Arm, where the maximum level reached by the highest tides is between 45 and 50 feet above the level of the lowest tides, boats anchored over the mud banks at high tide sink in the mud with the ebb and stand well above water in the deeper parts of the Arm at low tide, and thus are afforded protection against the dangerous bore that comes at the beginning of flood tide during those periods of the year when the tides are highest.

The Mud flats are gradually built up until shallow-water vegetation appears on the surface and then still higher with deposits from each inundation at flood tide, until thick vegetation takes hold, making the ground firm with its mass of roots, so that stock can graze safely on the high flats at low tide, while mowing machines can be used on the highest flats that are covered by water only by spring tides or during storms. In the upper part of Cook Inlet the water, kept in continual agitation by tides, is always extremely muddy, having a brownish appearance like mixed soil and water, so that sediments are readily dropped over the flats when the water is comparatively quiet at about the turn of tide.

The material forming the flats characteristically consists of bluish-gray or dark-gray silt loam, with some clay, which shows but little

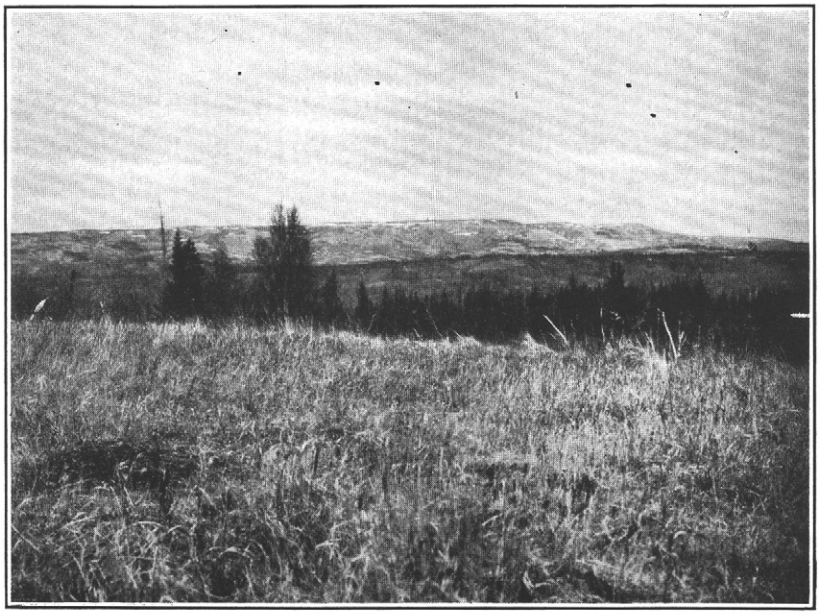


FIG. 1.—KACHEMAK VERY FINE SANDY LOAM, IN THE EDGE OF THE CARIBOU HILLS, NEAR THE HEAD OF KACHEMAK BAY.

Note level upland surface in foreground and lower-lying land and slopes in the middle distance.

FIG. 2.—RANCH HOUSE AND POTATO FIELD, 3 MILES FROM SEWARD.

change through a depth of 3 feet or more, except that beneath the surface 5 or 6 inches the color is of a more bluish gray and has occasional rusty-brown mottling. In places on the low flats gravel is reached within the 3-foot section. The silt is fine, and this, together with some clay, gives a firm body to the mass of the material. When wet the surface is rather sticky, but the foot seldom mires more than 4 or 5 inches deep, even in places not covered by vegetation. Peat bogs have been formed in places usually along the outer edge near the foot of the uplands.

The material is neutral to litmus. It contains in places considerable water-soluble salts, chiefly sodium chloride, which favors the growth of salt-loving plants like beach rye (*Elymus mollis*) and goose tongue (*Plantago maritima*). These two plants are the most conspicuous forms of vegetation on these flats. The beach rye makes good pasturage and hay for cattle and horses. There is considerable slough grass (*Carex* sp.), especially in the wet depressions back from the shore line. Buttercup or marsh marigold (*Parnassia palustris*) is another conspicuous plant on the flats.

A sample (No. 590216)[1] collected from the mud flats at Hope contained 0.265 per cent of water-soluble salts. A sample from a similar mud flat in southeastern Alaska, 7 miles west of Juneau, contained in the soil (No. 590265) 0.249 per cent water-soluble salts and in the subsoil (No. 590266) 0.141 per cent water-soluble salts.

Aside from its occasional use for pasture and for hay production, this land has no present value. By diking it probably could be reclaimed and used for growing vegetables and grain hay, and made more valuable for pasture and for the production of wild hay. At Hope it is reported that material from the mud flats has given good results with vegetables when mixed with garden soil of the Susitna loam and fine sandy loam types.

The following table gives the results of a mechanical analysis of the soil of the Mud flats:

Mechanical analysis of Mud flats.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
590216	Hope, Kenai Peninsula	Soil, bluish silt loam, 0 to 18 inches.	0.4	1.0	0.6	5.2	8.8	65.6	18.6

[1] See table on this page.

AGRICULTURE

INTRODUCTION.

On the basis of reconnoissance investigations it is estimated that there is an area of 1,000 to 1,500 square miles of bench and bottom land in the Kenai lowland which is sufficiently smooth and well drained to be used for crop production. Elsewhere through the peninsula there are strips of bottom and bench along the streams, such as Kenai, Snow, and Resurrection Rivers, and Resurrection, Sixmile, Glacier, Salmon, Quartz, Falls, and Indian Creeks, that likewise are susceptible of use without drainage. These lands lie below the timber line. All of the land can not be classed as first-class farm land for the reason that the soil is shallow and droughty in places, and locally the climatic environment is unfavorable. It is believed from the areas seen, from the results secured by scattered homesteaders, and from the results obtained in the Matanuska Valley on the same or similar soils, that fully three-fourths of this smooth land represents good farm land.

In addition to this there is a large area of good grass land—land supporting redtop, bunch grass, and other native grasses—not including the Muskeg areas. Grass flourishes over much of the slope land above timber line, native redtop and bunch grass being found in abundance in many places on the slopes up to about 3,000 feet and over the high Caribou Hill country, where the season may be too short for safe crop production.

The term "good farm land" is here used in a relative sense, meaning good farming land as farming goes in this far northern country, lying but 5° 30′ to 7° 30′ south of the Arctic Circle. It is known that many crops can be successfully grown here—are being successfully grown in small scattered patches—and that nutritious native grasses thrive in large quantity, that cattle, hogs, and chickens can be raised, and that good milk and butter can be produced on these native grasses and locally produced feed. With further experimental and plant-introduction work other crops and better varieties may be found suitable to climate and soil.

The better soils are quite productive, having, apparently, about the same degree of productivity as what would be classed as good farm land in the northeastern part of the United States. Some idea of comparison is had in the yield of 400 bushels of potatoes per acre, without fertilization, made in the Matanuska valley on deep Knik loam (or "Matanuska loam"), the best soil of the region. As to the durability of the soil, the agricultural history of the region is too brief for any definite conclusions; but the physical features and chemical analyses of the soil material do not indicate that it is of less lasting productiveness than the apparently similar land of old and proved agricultural regions. There are shallow, droughty soils here, underlain at shallow depths by beds of loose gravel, sand, and cobbles, which

are not retentive of moisture, and there are also areas of water-soaked muck and bogs of peat. Such lands are either unsuitable for farming purposes or are of low value, and are so considered in this report.

The principal immediate needs of the good farm land are lime or wood ashes, and thorough preliminary breaking of the soil to permit needed aeration of the material.

Land in this region is subject to homestead entry, under the provisions of the General Land Office and Forest Service.[1]

[1] Below are quoted some of the salient provisions of the law regulating homestead entry in Alaska, as given in Circular No. 1 of the Alaska Agr. Expt. Sta., Information for Prospective Settlers in Alaska:

"Farms on the public domain in Alaska can be acquired only in two ways: By homesteading the land under the homestead laws applicable to Alaska or by locating homesteads by the use of soldiers' additional homestead scrip. The latter method will probably not be used by farmers for the reason that scrip is becoming scarce and correspondingly expensive.

"The general homestead laws were extended to Alaska, with certain modifications, by the provisions of the act of Mar. 3, 1903 (30 Stat., 1028). Agricultural lands lying within the national forests of Alaska may be entered under the provisions of the act of June 11, 1906 (34 Stat., 233), and acts amendatory thereto. Intending settlers should apply either to the General Land Office, Washington, D. C., to the Juneau land office, Juneau, Alaska, or to the Fairbanks land office, Fairbanks, Alaska, for copies of the law applicable to the unreserved public domain, or to the forest supervisor, Ketchikan, for copies of the act of June 11, 1906.

"It is impracticable to quote the law in full here. There are many points in the law which a settler should understand. Its general features are as follows:

"(1) Any person who is qualified to enter a homestead under the general public-land laws may locate 320 acres, reduced to 160 acres in 1916, of land in Alaska, provided, however, that if the location is made within a national forest, under the provisions of the act of June 11, 1906, he can locate only 160 acres. The land so located must be agricultural land; that is to say, mineral-bearing land can not be taken up for agricultural purposes under the homestead law.

"(2) The location must not encroach upon Government reservations or mission sites, nor can lands on which there are hot springs be located for homestead purposes.

"(3) The homestead should be laid out in rectangular form, and the lines should run due north and south and due east and west. If on surveyed land, the lines are of course already established; but on unsurveyed land the homesteader must bear the expense of the survey, and such survey must be made by a United States deputy land surveyor, and the survey must be approved by the authorities of the General Land Office.

"The homestead must not exceed 1 mile in length, and when it is located on navigable water it must not exceed 160 rods along the shore of such navigable water; and, further, on navigable waters a homestead can not be located nearer than 80 rods to an existing claim; that is to say, the law reserves a space of 80 rods between homesteads on navigable waters so as to make access to such waters available to the general public.

"(4) The locator must establish his residence on the land within six months from the date of location; during the second year, one-sixteenth of the area of the homestead must be brought under cultivation; and during the third year, one-eighth of the whole area must be brought to cultivation. The fact that the homesteader uses the land for meadow and pasturage is not accepted in lieu of cultivation. The land must be broken and crops must be raised upon it.

"(5) The homesteader can obtain leave of absence from his residence on the homestead not to exceed five months in any one year. This provision makes it possible for him to earn money by work elsewhere. At the end of three years from the date of location, and up to five years, patent may be applied for.

"(6) A homesteader may acquire title to 160 acres by the process known as 'commutation of homestead entries.' He must, in that case, show that he has established and maintained his residence upon the land for at least 14 months continuously, and must have put the required area under cultivation. These conditions complied with, he must pay for the land, at a rate fixed by the General Land Office, of not less than $1.25 nor more than $2.50 per acre."

For further information, see Circular No. 414, "Suggestions to Homesteaders and Persons Desiring to Make Homestead Entries," issued by the General Land Office, Department of the Interior, Washington, D. C.

There are limitations upon crop production imposed by climate and unfavorable economic conditions that confront the establishment of an important agriculture here with obstacles that deserve serious consideration. With the short growing season it is improbable that crops like corn, apples, and melons can ever be grown in the open; it may not be found that the growing of grain, except for hay, or chicken and hog feed, can be successfully carried on upon a large scale. At present the home markets are restricted by the small population; there are but few roads, none in the most important part of the Kenai lowlands; the cost of labor and of food and clothing are high, and means of transportation are inadequate and the freight rates high. Under present conditions this is not a country into which men with small capital or those looking for immediate large profits from farming should go in large numbers; and those who do go to the region should first acquaint themselves fully with the conditions of climate, soil, transportation, and means of communication, with the crops that are known to succeed, and with the geography of the region.

The economic conditions referred to above are susceptible of improvement; the climatic conditions are not, although crops may be adjusted in some degree to the climate. If mining operations are largely increased, attracting a much larger population, there will thus be afforded a larger home market for the sale of farm products. In this connection it should be stated that large quantities of beef, pork, chickens, butter, eggs, canned milk, and even potatoes, cabbage, turnips, and lettuce, which are products that can be produced here, are now being shipped in from the outside. Thus, before considering the exportation of farm products, the problem of supplying the home needs should be solved. This will mean the cultivation of additional land and the introduction of more cattle, hogs, and chickens. The farmers of Matanuska Valley and the adjacent country probably will soon be growing about all the potatoes, cabbage, turnips, and several other vegetables needed by Anchorage and the other towns of upper Cook Inlet, unless the population is very largely increased, while the vegetables and most of the milk, eggs, and chickens needed at the villages of Kenai and Ninilchik are locally produced. With cheaper transportation it is believed that the raising of the more hardy breeds of cattle can be made the basis of an export trade. With the long winters, during which cattle must be fed, and the long distance to outside markets, cattlemen in this region may have to content themselves with a much smaller margin of profit than where the winter season is shorter and where winter range is available. These are problems that remain to be solved. There is no question about the possibility of producing adequate foodstuffs not only for cattle, but for hogs and chickens. It

is easy to produce heavy yields of potatoes, turnips, and other vegetables that can be used for stock feed, and grain hay of good feeding value can be easily grown, while native hay and pasturage can be had in great abundance in many localities.

The timber of the region should be carefully preserved for use in building houses, barns, and fences. The last two mentioned will be important items in connection with live-stock industries. Continuation of the present wastage of the timber by forest fires can but add cost to future farm operations, and each item added to the cost of production makes agriculture here less likely to prove economically successful.

In considering the opening of the Kenai lowlands to cultivation it will be well not to lose sight of the fact that here is one of the best, if not the best, big game countries on the continent, at least for moose. The mountains to the rear of the lowlands are the home of large numbers of mountain sheep. If the country is farmed this game will disappear, at least the moose will be crowded out and eventually the sheep killed off, unless very stringently guarded or unless game sanctuaries properly patrolled are established. The gradual settlement of the country, which probably will be the way settlement will proceed, will allow the big game to hold out for a considerable period, and eventually other parts of the Territory not so promising from an agricultural standpoint, and already containing much game, may be developed as game ranges equally as valuable as the Kenai Peninsula.

With its large area of productive soil it is believed this part of Alaska will eventually support an important agriculture, built up gradually and conservatively, accompanying an increase in the mining and fishing population, and in time worked out along lines that will overcome obstacles in the way of exporting farm products. There is no question as to the possibility of establishing farms which will be practically self-sustaining—farms that will produce all their needed dairy products, meat, eggs, potatoes, and vegetables. A few are now practically doing this on the peninsula, and this has been accomplished in some cases by men who have previously had little experience with farming operations. There are no large farms at present, only patches under cultivation, rarely more than 3 or 4 acres in one body, and the total number of cows, hogs, and chickens on the entire peninsula is small, as is also the total population. Some gold and coal mining are carried on, and very important fishing industries have been developed along the coasts. These industries may have considerable bearing upon the development of agriculture. Some of those now operating small vegetable patches and raising a few head of cattle devote much of their time to fishing, and others work at the mines or spend their time in prospecting. With

available work in these other industries, a farmer with small capital can thus find some assistance in carrying on development work upon his farm.

In the following chapters data are presented bearing upon the crops that have been found suitable and some of those that may be found suitable to the region, and upon methods of clearing and handling the land, raising stock, means of communication, mining and fishing industries, game, and other economic features and resources.

POTATOES.

Potatoes are regularly grown in all the gardens seen on Kenai Peninsula. They are grown only in small patches for home use. (Pl. XXI, fig. 2.) All the homesteaders produce their needed supplies of this vegetable, and at Ninilchik and Kenai potatoes are but rarely imported. The crop is successfully grown near Seward, along Kenai and Skilak Lakes, along Resurrection and Sixmile Creeks, and at all the settlements and villages along the shores of Cook Inlet and Kachemak Bay, and by every homesteader and prospector having a cabin.

Both the bench lands and bottom lands (Knik and Susitna soils) are used in the production of potatoes. Best average results are had on the early, well-drained, southward-facing slopes and flats. The medium deep and deep phases of the Knik loam and the well-drained Susitna loam, silt loam, and fine sandy loam are the most desirable soils upon which this crop was seen, judging by the appearance of the growing crops. The Kachemak very fine sandy loam apparently possesses all the characteristics of a desirable potato soil, and in favorable situations very likely would give excellent results. Soils similar to Kachemak soils are considered ideal potato soils in various parts of the United States.

Best results are had where the soil has been cultivated two or three years and where manure is used. A rancher and trapper on the west shore of Skilak Lake used fish scrap this year (1916) for potatoes with particularly good results. Kelp has been used with good results at Seldovia. On soils like the Knik loam exceptionally good crops of potatoes have been grown where brush piles have been burned.

The potatoes yield well as a rule. Yields of more than 300 bushels per acre are reported in Matanuska Valley without the use of any kind of fertilizer. Occasionally cold summers and unseasonable frosts retard the growth, with the result that the yield is short and some of the tubers do not mature perfectly. In such cases the tubers are of inferior quality and better suited for use as food for stock than for human beings. But with normal seasons potatoes of good

mealy quality are produced on the well-drained flats and southerly slopes.[1] Where the drainage is imperfect, and on the cooler northerly slopes, and in those places where cool winds sweep down from the glaciers it can not be expected that potatoes of the best quality can be grown, and such soil and situations should be avoided, if other ground is available.

The Early Ohio is generally considered the best potato for the region, giving good yields of tubers of large size and good quality. The Early Rose and other varieties are grown to some extent. Experience shows that some advantage in the matter of insuring maturity can be had by sprouting the seed potatoes before planting.[2] Planting can usually be done about the middle of May, but at this season the ground may be rather cold, so that growth will not be as rapid as where the seed has previously been sprouted. It is not the general practice, however, to sprout before planting; nevertheless, good average results are had with the crop.

There is so much land that will give thoroughly satisfactory results with potatoes that it is safe to conclude this crop is destined always to have a leading place in Alaska agriculture.

OTHER VEGETABLES.

Cabbages of excellent quality and large size are also grown in nearly every garden. The crop succeeds on the good potato soils and also, when proper drainage is established, on the mucky soils.

The Early Jersey Wakefield has proved the most satisfactory variety. Among other varieties grown are Copenhagen Market, Early Flat Dutch, and Early Winningstadt. Solid, large heads of crisp texture and sweet taste are generally obtained. Transplanting from cold frames should be done about the last of May. Additions of manure, wood ashes, and fish scrap have given good results wherever used.

Cauliflower is another plant that does remarkably well here. It produces large, crisp, well-flavored heads. The plants are handled in the same way as cabbage. Broccoli, a plant similar to cauliflower, can be grown in the same way as cauliflower and cabbage. Broccoli

[1] "If potatoes are grown on well-drained ground, if early varieties of good quality are selected, and if the seed is sprouted before planting, as good potatoes can be grown in Alaska as anywhere on earth." Annual Report, Alaska Agr. Expt. Sta., 1912, p. 14.

[2] "Sprouting the seed before planting is a very important factor. * * * A good way to sprout potatoes is to take a shallow box and put an inch of soil in the bottom, and then pack the potatoes closely in one layer, and partly cover with a very thin layer of soil. If one has a cold frame, boxes thus prepared can be placed in this, and the potatoes will sprout as they would in a warm room. If no cold frame is available, set the box in the house, preferably near the light. * * * When the potatoes have sprouts 3 or 4 inches in length, if the planting is then done carefully, leaving the tips of the sprouts in the surface of the soil, the potatoes will continue to grow and tubers will be ready to use a month earlier than would be the case if the seed had not been sprouted." Annual Report, Alaska Agr. Expt. Sta., 1912, p. 14.

planted in a hotbed at the Kenai station, April 26, and transplanted to open ground May 29, grew well and formed a good percentage of heads.

Some kale is grown in this region with very good results. The results of experiments with this crop, to quote the report of the Alaska experiment station—[1]

> Show that one of the chief merits of kale is that it is a winter vegetable. It can stand a moderate degree of frost, and indeed its quality is improved by freezing slightly. In the coast regions it can, therefore, be left outdoors the entire winter and cut as needed. In very cold weather a foot or more of snow is a protecting blanket to the plants. * * * The dwarf curled varieties are to be preferred. The tall, coarser varieties can be grown for cattle feed, the only objection to this being that they will flavor the milk, as do turnips, cabbage, and all other Cruciferæ.

Brussels sprouts were grown at the Kenai station, but did not develop satisfactorily, at least not in the experiment in 1906. The plant is reported as having succeeded at the Sitka station. Cabbage, cauliflower, broccoli, kale, and Brussels sprouts all require about the same treatment and succeed on the same soils.

Turnips are grown in all gardens. This vegetable is of about the same importance in Alaska as cabbage, being grown probably somewhat more extensively. The white varieties are frequently damaged by the root maggot, but the Petrowski turnip and the rutabaga are much more resistant, the former being almost exempt from attack. The Petrowski, a yellow turnip, is one of the best known. It does well throughout Alaska, making very large, solid roots, often weighing more than 5 pounds, and it is of a sweet flavor. The seed was obtained in Finland, and has been distributed by the Alaska experiment station.

Turnips succeed on the well-drained soils generally throughout Alaska. Applications of manure increase the yields materially, and in one instance on Skilak Lake, fish scrap was used with good results. The roots attain such large size that it is believed the crop could be made important as a stock feed.

Radishes of various varieties are grown very easily, when not attacked by the root maggot, which frequently damages the crop.

Lettuce does splendidly on the loam, silt loam, and sandy soils and on well-drained muck lands. All varieties, both the loose and solid headed, produce well. The loose-headed varieties are earliest. Solid-headed lettuce, seeded in June, will have well-developed heads in August or early September. These heads can be kept until late in winter, it is said, by storing them in a dry frost-proof cellar.

Carrots are sometimes grown in this part of Alaska. Very good roots were seen in some of the gardens. Beets are frequently grown,

[1] Annual Report, Alaska Agr. Expt. Sta., 1912, p. 19.

but they usually do not attain a very large size. These crops will do best on the well-drained soils, in sunny situations. Beets 5 or 6 inches in diameter have been grown on the Susitna loam at Hope. Mangel-wurzels were not seen. It is probable that this valuable stock feed can be produced on the well-drained early soils, and perhaps even on drained muck. Onions are usually small. They are grown both from the seed and from sets. A wild onion, which is abundant in places above timber line and also grows at lower levels, as, for example, along the benches at the lower end of Kenai Lake, is sometimes eaten. It is far better than the common wild onion of the United States.

Spinach, rhubarb, mustard, garden peas, and Swiss chard all do well. Garden peas attain an exceptional height and fruit well. Vines 6 feet high and heavily laden with peas were seen in a garden at Anchorage in July. The early varieties will mature their seed in normal seasons.

Spinach, small onions, turnips, greens, and radishes are sometimes sold from the local gardens by the middle of June.

At Hope it is reported that success has been attained with string beans. Only the earliest varieties[1] of this vegetable should be grown, and these only in sunny situations on well-drained soil, such as the Knik loam and the Susitna loam and fine sandy loam. Tomatoes have not given much encouragement to those who attempted to grow them in the open. The very earliest varieties, well started before transplanting, and transplanted in sunny situations on well-drained sandy or loose loam soil, may produce some fruit in favorable seasons.

A number of native plants are used for greens. Goose tongue (*Plantago maritima*), one of the most abundant plants on the mud flats, makes a delicious dish when the tender young leaves are boiled. Most people prefer it to spinach. This plant is said to be canned for winter use in some parts of Alaska. The young plants of fireweed, marsh marigold, and the curly heads of ferns ("fiddle heads") are sometimes eaten as greens.

Celery of good quality and size was grown at the Kenai experiment station by seeding in the hotbed April 26, and blanching with boards. Little effort has been made to grow this crop elsewhere in this part of Alaska, but it is grown about Fairbanks with excellent results.

During the period from the summer of 1915 to the summer of 1916, inclusive, home-raised products sold on the Anchorage market

[1] At the Fairbanks experiment station in 1915 Early Red Valentine and Stringless Green Pod beans succeeded. The 1915 Report of the Alaska Agricultural Experiment Station says: "Early Red Valentine and Stringless Green Pod beans were planted in deep furrows May 14, after the furrows had been wet with a sprinkling pot. They came up very quickly and made rapid growth. The vines blossomed freely and were full of pods. The first beans were picked July 23, and from that date both varieties bore heavily until the end of September."

as follows: Potatoes, $3 per 100 pounds; cabbage, 4 to 6 cents per pound; lettuce, loose leaf, 10 cents per bunch, 3 bunches for 25 cents; lettuce, solid headed, 10 cents per quarter pound; carrots, $4 per 100 pounds; turnips, 25 cents for 3 bunches of 5 each and about $3 per 100 pounds; beets about the same as turnips; parsnips about the same as carrots; spinach and kale, about the same as lettuce.

Produce shipped in from Seattle during the same year sold as follows: New potatoes, $4.50 per 100 pounds; fall potatoes, $3.50 per 100 pounds; cabbage, 4 to 6 cents per pound, or 3 heads for 25 cents.

Prices of some other products, such as hay, eggs, and milk, are given in following pages.

CULTIVATED AND WILD BERRIES.

Strawberries are being successfully grown in small gardens on Kenai Peninsula. Plants obtained from the experiment station at Seward did splendidly this year (1916) in Mrs. Borgen's garden at Seward. (Pl. XXII, fig. 1.) A single vine was reported to have produced this year 130 berries. The berries are medium in size and of good flavor.

Wild red raspberry was seen in a number of places along the shores of Skilak Lake, near the lower end of Tustumena Lake, and elsewhere. The canes bore good fruit. Good results have been had with cultivated raspberries in the gardens about Seward and at Hope.

Besides the red raspberry many native berries flourish throughout this region. The most important of these are low-bush cranberry, high-bush cranberry, red currant and at least two varieties of black currants, and several varieties of blueberries.

The low-bush cranberry is very plentiful and widely distributed, growing in well-drained situations both in the woods and open places below timber line. It is never found on marsh land or Muskeg. In the burned areas of the Kenai lowlands the berries can be gathered in large quantities, ripening after the middle of August. These cranberries are much used in making preserves or jam, which is as good as that made of the cultivated cranberries of the United States.

The so-called high-bush cranberry is plentiful through the woods, and is often found in open places. Jelly is made from it.

The blueberry is abundant in many places on Muskeg and in open places above the timber line. Blueberries or huckleberries of very large size are found in abundance in the vicinity of Seward and elsewhere. These berries are frequently used in pies, and while they may not be so sweet as some of the huckleberries of the United States, they are much prized locally.

Wild currants are abundant in the stream bottoms and in the woods and open places of the bench lands. The red variety is much

used for preserves and jelly. (Pl. XXII, fig. 2.) One of the black currants, the "musk" or "skunk" berry, does not have a pleasant odor but makes good jam. The black varieties seem to be most abundant on the timbered slopes.

The service berry is found in some places, as, for example, on Burnt Island. The fruit makes good jam. Among the other native berries considered edible are the squawberry (*Rubus chamæmorus*), also known as "baked apple" and "morooski," found on Muskeg and where moss is abundant, bunchberry (*Cornus canadensis*), sand berry (*Rubus pedatus*), "watermelon" berry (*Solomon seal*), partridge berry, moss berry, and the berry of the wild rose.

FLOWERS.

Numerous flowering plants, both wild and cultivated, thrive in this region. A number of the cultivated varieties blossom beautifully, and the flower gardens are a conspicuous feature of every village. Among the more common are the nasturtium, pansy, poppy, and sweet pea. These produce especially large and attractive flowers, the nasturtium and sweet pea often climbing to the eaves of single-story houses. Other flowers that bloom profusely in yards and gardens are the forget-me-not, China pink, snapdragon, phlox, petunia, purple, blue, white and pink asters, white and pink daisies, sweet alyssum, marigold, bachelor-button, baby-blue-eyes, red, purple, and pink Virginia stock, white and variegated dwarf morning-glory, "Alaska" or Iceland poppy, California poppy, oriental poppy, sweet William, Canterbury bells, columbine, rosa rugosa, and mignonette. These flowers do well on the well-drained soils of the region. Ashes and manure give increased luxuriance, at least to many of them.

The most abundant wild flowers are fireweed, bunchberry, wild rose, Hudson Bay tea, lupin, and several kinds of "bluebells." These grow abundantly from the benches to the timber line and frequently above the timber line. The low white flower of bunchberry (*Cornus canadensis*), which resembles the blossom of the dogwood, practically covers the ground in many places throughout the woods in July and early August. In open places the coral-pink blossoms of fireweed (*Chamænerion angustifolium*) are so thick in August as frequently to give the appearance of a fire when seen from some distance, and in September the bursting pods with their white, silky fiber give the land the appearance of fields of open cotton.

Solomon's seal, wild celery, *Geranium erianthum*, having a white flower; *Pyrola uliginosa*, having a small white flower on a long stem; *Potentilla alaskana*, with a small yellow flower resembling buttercup; various "bluebells" (*Campanula alaskana*, *Dodecatheon jeffreyi*, and *Aconitum delphinifolium*); large lupin (*Lupinus*

nootkatensis unalaschensis), and others are common flowers in timber or open places. *Andromeda polifolia*, a very low-growing plant with small flowers like mountain laurel, is occasionally found on well-drained land. In marshes and wet places marigold (*Parnassia palustris*) is abundant, and *Valeriana sitchensis*, bearing a roundish cluster of small fragrant white flowers, *Sanguisorba sitchensis*, having a fragrant white small cat-tail-like flower, and flags are found in places. A yellow-flowered water lily is plentiful in the lakes.

Above timber line short golden-rod (*Solidago multiradiata*), several kinds of aster, ptarmigan berry (*Arctus alpina*), white and blue violets, bluebells, and numerous other flowers are plentiful, some blooming until the heavy frosts of September.

GRASSES AND FORAGE PLANTS.

Native grasses grow in abundance in many localities throughout the Cook Inlet region. Native redtop or bluetop (several species of Calamagrostis—*C. canadensis*, *C. inexpansa*, and *C. scabra*—being the varieties most abundant) and bunchgrass or fescue (*Festuca rubra kitaibeliana* and *F. altaica*—Siberian fescue—*F. rubra lanuginosa* being the varities identified) are the most plentiful grasses. These were seen throughout Kenai Peninsula, redtop being most abundant in the glades of the timbered areas and over sparsely timbered slopes from near sea level to 1,000 feet or more above timber line. (Pl. XXIII, fig. 1.) It is particularly abundant in open places among the alder thickets so conspicuous in a zone skirting the upper limits of timber. The largest body of heavily grassed land the writer has ever seen, not excepting the luxuriant meadows of Para and Guinea grass in Central America, is that of the natural meadows of redtop occurring on the flats, slopes, and benches skirting the northern shore of Kachemak Bay. (Pl. XXIII, fig. 2.) Here there is a strip extending from Homer Spit to Fox Creek, containing between 30 and 40 square miles, the greater part of which was densely covered with redtop from 4 to 9 feet high. A homesteader on Fox Creek reported having cut 4 tons per acre. Apparently the yield will run usually from 2 to 4 tons per acre. On this strip it is believed that from 40,000 to 50,000 tons of redtop hay annually go to waste. (Pl. XXIV, fig. 1.) Much of it could be cut readily with mowing machines by chopping out a few bushes and small trees, and the remainder with the scythe. Numerous other redtop meadows were seen through the Kenai lowlands, on the high slopes, and above timber line on Big Indian Creek and Skilak Lake and in the stream bottoms. This year (1916) about 30 tons of redtop hay were put up by a homesteader at Anchor Point, and a number of

other stacks were seen on Kachemak Bay, at Ninilchik, near Kenai, about Seward, and about the head of Kenai Lake. (Pl. XXIV, fig. 2.)

The acreage yield of redtop may diminish with continuous cutting, yet a homesteader on Fox Creek on Kachemak Bay reported this year (1916) a yield of 2½ to 3 tons per acre from a field that had been cut for three consecutive years. The grass is slow to reestablish itself over the big burns where the seed has been destroyed by fire. By scattering seed through the burned areas it is possible that a good stand could be quickly and cheaply established.

Bunch grass was also seen in many places on the benches and mountain slopes. It was found in greatest quantity on the high benches where there is not much redtop. In some places it contains a scattering of redtop. In areas above the timber line the redtop usually gives place to bunch grass at 2,500 to 3,000 feet. It is said that in the Caribou Hills country bunch grass is present in great abundance. Much of it was seen along the edge of these hills near Kachemak Bay.

Other native bench-land and slope grasses found locally in considerable quantity are wild timothy or wild barley (*Hordeum montanense* and other species), bluegrass (*Poa pratensis*, *P. hispidula*, *P. palustris*, *P. acutiglumis*), and "mountain timothy" (*Phleum alpinum*).

Mountain timothy, a short barleylike grass, forms an important part of the pasturage of mountain sheep and goats. Bluegrass was seen on the high benches near the head of Kachemak Bay, at Kenai, and in other places on the peninsula. The other grasses were seen on well-drained bench lands about Kenai, Ninilchik, and elsewhere. Still other bench-land grasses reported are[1] *Agropyron riolaceum*, *Alopecurus alpinus*, *Bromus richardsonii*, and *Deschampsia cæspitosa*.

Slough grass (*Carex* sp.) is abundant in many wet places, especially in the peat bogs of the mud flats. Beach rye (*Elymus mollis* and *E. arenarius*) is the most valuable grass of the mud flats and sandy and gravelly beaches. This grass is used at the Kodiak livestock experiment station as the principal plant for ensilage. Other mud-flat plants that afford some grazing are goose tongue, red fescue, and *Puccinellia*.

Redtop, bunch grass, slough grass, beach rye, bluegrass, and the fescues afford excellent grazing, and redtop, slough grass, and beach rye (along with other mud-flat grasses) are cut for hay. At the dairy operated near Seward by Adelman & Quilty redtop is used for ensilage. All of these are valuable feed grasses. One occa-

[1] Annual Report, Alaska Agr. Expt. Sta., 1904, p. 273.

sionally hears it stated that redtop, which is the most valuable grass of the region, owing to its great abundance and wide distribution, is not a good hay grass; but such statements do not accord with the facts. Native redtop hay, cut at the right time, which appears to be after the seed has begun to form and before it has ripened and before frost has toughened the fiber, has in all instances where tried proved a nutritive feed. It possesses about the same value as timothy hay. Both cows and horses thrive on the green grass, and in many cases in the Cook Inlet region the hay has been the only, or practically the only, feed used through winter for both cattle and horses. Of course the hay alone is not a well-balanced ration, and as with other grass hays, some feed, such as grain or leguminous hay, should be added to the ration. When the grass has grown old and tough or has been hardened by killing frost, the hay may not be expected to be readily digested.[1]

Slough grass has been cut to some extent for hay. It is said to make good hay if cut at about the time the seed is well formed. In the Tanana Valley of interior Alaska some of those who have used this hay say that it is even better than redtop hay. The difficulty with it is that its habitat is wet ground, usually unfavorable to the use of mowing machines.

Bunch grass is said to afford good grazing, even after being killed by frost. If this is true, there are many places where it could be used for fall pasturage, or until snow covers the ground deeply, which usually is not before November. There is said to be a great deal of bunch grass through the Caribou hills. There was much in that portion of the Caribou hills seen by the reconnoissance party.

In a report on the Kenai Peninsula[2] occurs the following statement in regard to the grasses of the region:

> Native grasses are abundant, especially in the Cook Inlet region, which contains broad areas of natural grassland. There is also a considerable aggregate area of patches of grassland in the mountain province, especially around timber line and in the upper timberless parts of the valleys. There is no difficulty in finding good forage for horses during the summer in almost any part of the peninsula, except along the rock-bound coast. Considerable hay is made in the peninsula, especially in the vicinity of Hope, Sunrise, and Seward. In the Sunrise country native hay in stacks brings $10 to $12 a ton, and late in the winter occasionally $20 a ton.

The wild peas of the Cook Inlet region are keenly relished by stock. There is an abundance of the large wild pea, beach pea (*Lathyrus maritimus*), on the gravelly beaches and slopes of benches, and a smaller wild pea (*Lathyrus palustris*) is locally abundant in

[1] See analysis and discussion of forage plants, pp. 82–86, Soil Reconnoissance in Alaska, Field Operations of the Bureau of Soils, U. S. Dept. of Agriculture, 1915.

[2] Geology and Mineral Resources of Kenai Peninsula, Alaska, Bul. U. S. Geol. Survey, No. 587, pp. 28–29.

the stream bottoms and on the beaches and bench slopes. Both of these plants are greedily eaten by cows and horses. Hogs also probably would relish them. A report[1] on dairy practice at the Kenai station states that—

> The plants that form the major portion of their [the cows'] ration in summer are the blue top, June grass, bunch grass, and wild pea. They seem to prefer the latter above all others, and its value as a milk producer is above question.

These native legumes might prove successful field crops, especially on sandy and gravelly soils like those upon which they grow in the wild state, but so far as the writer is aware no attempt has been made to grow them anywhere in Alaska. The large pea produces seed abundantly, and experimental plots could easily be planted.

Among the other native plants eaten by horses and cows are joint grass (*Equisetum palustre* and other species), which grows plentifully nearly everywhere; fireweed (*Chamænerion angustifolium*), growing profusely in all open well-drained situations; wild potato or Indian potato and a plant bearing seed like the common sticktight (probably *Astragalus* sp.), which are common on sandy and gravelly bottoms, and chickweed (*Alsine media*), which grows abundantly about many clearings and is much relished by hogs. Large lupin (*Lupinus nootkatensis unalaschensis*) is exceedingly abundant in the Kenai lowlands and is often unavoidably mixed with the redtop hay when cut. It is reported to be readily eaten by sheep.[2] Fireweed is also frequently mixed with the hay. It is eaten by horses, cattle, and sheep.

Of the cultivated grasses timothy appears to be the most successful. This year (1916) about 10 tons of timothy hay were cut near the Government railroad about 7 miles from Seward. Here on an alluvial soil (the Susitna silty clay loam) about 1 ton per acre was produced on rough stump land very unevenly and otherwise inefficiently prepared and seeded. At the Kenai station timothy gave best results of a number of grasses tried, including orchard grass, true redtop, smooth brome-grass, meadow foxtail, tall fescue, and tall oat-grass. Timothy has not done well in several instances on fresh bench land (shallow Knik loam) in the vicinity of Knik. Better success may be expected where the soil has been cultivated a while or where manure is used. Applications of lime and of fish scrap may be of value in the growing of timothy.

White clover is frequently seen in small volunteer patches throughout the region, often growing in large bunches. It is believed this crop will prove a valuable legume for this section. So far practically nothing has been done in the way of cultivating this plant. Alsike

[1] Annual Report, Alaska Agr. Expt. Sta., 1907, p. 63.
[2] Idem, 1904, p. 274.

is reported to have made a vigorous growth at the Kenai station. Red clover was noticed in volunteer growth in several places about Cook Inlet. The Canada field pea has been grown more than any other legume. It has done well in a number of fields on the bench land (Knik loam) near Knik and in the Matanuska Valley.

Garden peas make such luxuriant growth that it may be practicable to use this crop as a hay and field-forage crop. Planted early, the early varieties will mature their seed in normal years.

Vetch is another legume that succeeds here. At Anchorage vetch mixed with oats made substantial growth this year (1916) on fresh shallow bench land (Knik loam).

It would seem that one or more of these legumes could be depended upon to produce the needed leguminous forage for stock and to meet the requirements for good soil-improving and humus-supplying crops—crops to be plowed under to increase the supply of vegetable matter and nitrogen in the soil.

The most valuable forage crops for the region probably are oats and barley. Large yields of oat and barley hay can be produced every year on the better grades of land, and even the deep sandy soils and shallow bench land with gravel near the surface give fair yields, especially when a little manure is spread over the land. It is possible that these grain crops might at rare intervals be ruined by unseasonable frosts, but records of such damage in the Cook Inlet country have not reached the attention of the writer. Oat hay was considered the best winter feed for the cattle at the Kenai station, in discussing which a report[1] of that station says:

> In winter their [the cattle] feed consists almost wholly of oat hay. This plant is chosen for its quick growth, comparatively heavy yield, and its excellent feeding qualities * * *. The oats are cut while in the milk stage, at which time they are best for hay. Oat hay is a palatable feed, greedily eaten by all stock.
>
> These conditions [climatic] suggest that the coast region is more particularly suited to the production of cattle feed, and the writer predicts that in the future large quantities of grain will be grown for ensilage on which to feed stock through winter. These same conditions are also conducive to a luxuriant growth of grasses and clovers. Red, white, and alsike clovers all do well almost everywhere in the coast region, but alfalfa, on the other hand, has so far not been a success. Peas, vetches, root crops, kale, etc.—in short, every form of hardy feed stuff—can be grown with marked success throughout this region, and the same holds true of all sorts of vegetables. The coast region of Alaska is, therefore, preeminently adapted, first, to market gardening, * * * and, secondly, to stock raising and dairying. * * *

In the sunny weather that obtains much of the time in the Cook Inlet region it is very easy to cure both grass and grain hay. Cut in the morning, such hay will be ready for the stack or barn the

[1] Circular No. 1, Alaska Agr. Expt. Sta.: Information for Prospective Settlers in Alaska, p 18.

FIG. 1.—STAWBERRIES IN GARDEN AT SEWARD.

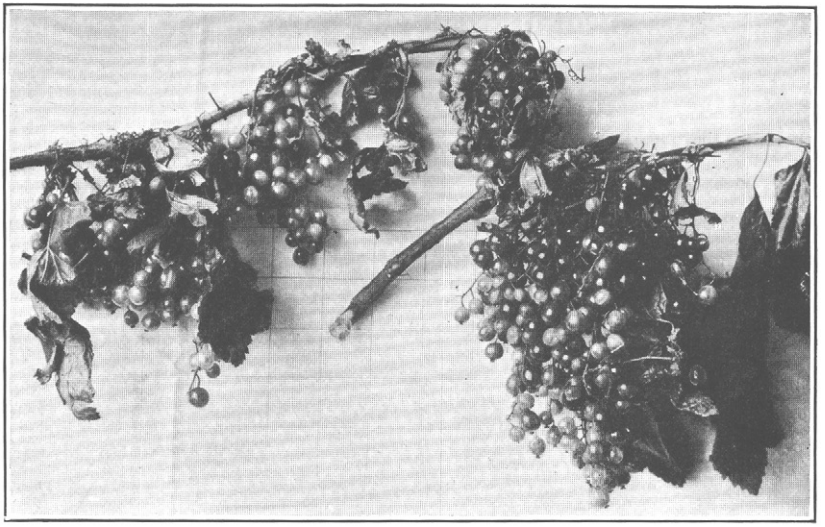


FIG. 2.—RED CURRANTS PICKED JULY 30, 1916, FROM DEEP KNIK LOAM, 5 MILES SOUTH OF ANCHORAGE.

These delicious native currants are picked throughout the Cook Inlet region. The squares in the photograph have a dimension of 1 inch.

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FIG. 1.—REDTOP GRASS ON THE NORTH SIDE OF INDIAN CREEK, AT AN ELEVATION OF 2,000 FEET.

The illustration shows the luxuriant growth of this grass, even above the timber line.

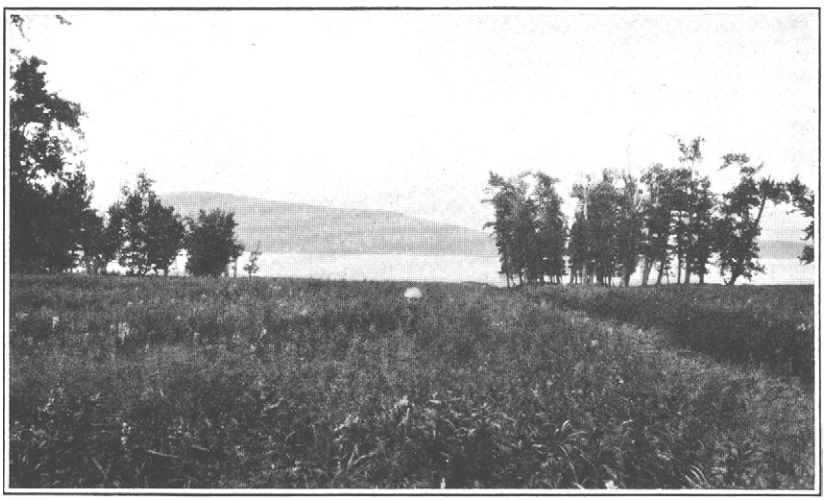

FIG. 2.—NATIVE GRASS, MAINLY REDTOP, ON FLAT NEAR UPPER END OF KACHEMAK BAY.

This is a natural meadow, ready to cut with a mower.

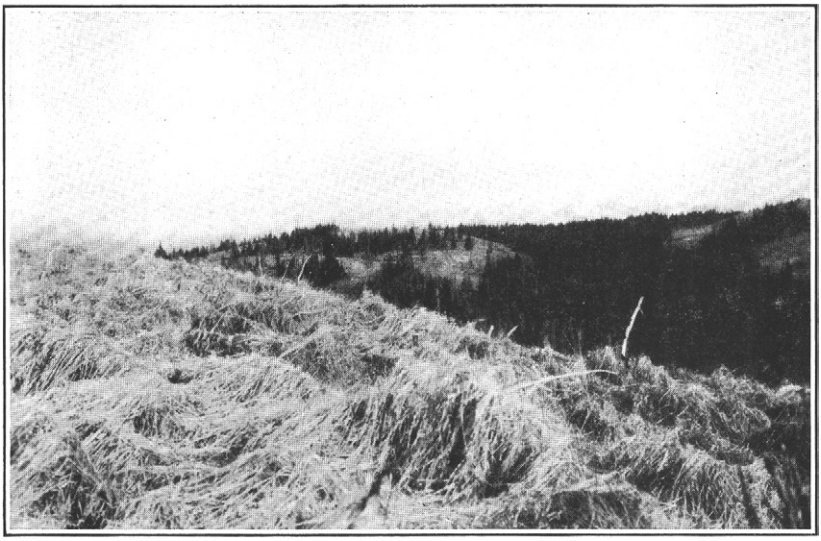

FIG. 1.—PRECEDING YEAR'S GROWTH OF REDTOP, WHICH HAD BEEN COVERED WITH SNOW DURING THE WINTER, BACK OF BEACH AT HOMER.

Many thousands of tons of this valuable hay, ensilage, and pasture grass go to waste yearly in these natural meadows.

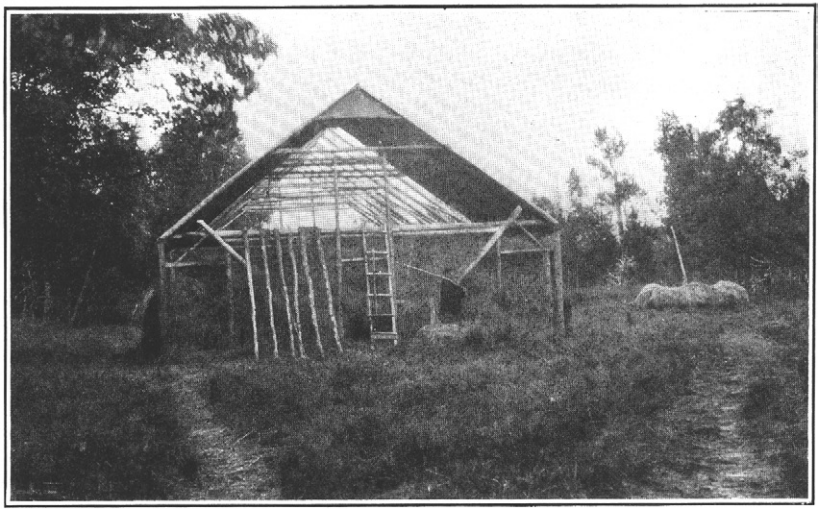

FIG. 2.—NATIVE HAY STORED IN 1916, NEAR MOUTH OF FOX CREEK, ON KACHEMAK BAY.

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FIG. 1.—CATTLE RAISED AT NINILCHIK.

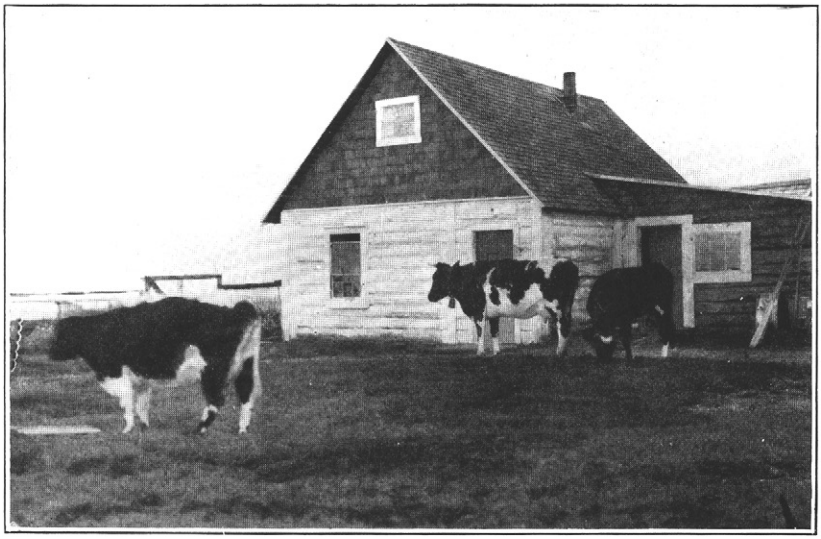

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FIG. 2.—MILCH COWS AT KENAI.

afternoon of the following day. On a hot day this grass will cure well in one day. But in cloudy weather, which is of frequent occurrence and long duration some years, all grasses cure slowly, the plants frequently lying on the ground for days with but slight wilting. This feature, however, is not so discouraging as it might seem at first thought. The air is always cool when the sky is overcast, and decomposition is accordingly slow. Grass or grain will lie in the swath for days during rainy or cloudy weather without showing the slightest deterioration. The writer saw timothy this year (1916) near Seward that had lain cut and had been rained on for nearly a week without showing even a change of color. It is possible a very dense growth of grass or grain might deteriorate in a thick-packed swath, but by scattering this about with fork or hay tedder occasionally it is not likely that much damage would result in cloudy or rainy weather. Thus it will generally be possible to save all hay by simply waiting for sunny weather, if the sky should cloud over before the hay is cured, so that the matter need not occasion much concern. Even should bad hay-curing weather continue, the grass could be stored in silos.

Oats, beach rye, and native redtop were used satisfactorily for silage at the Kenai station. Redtop is being used in the silo near Seward, while beach rye is the principal silage plant at the Kodiak live-stock station. Silage has given good results with milch cows.

It is believed that the pit silo[1] could be employed with especial satisfaction here, since there are many well-drained slopes or bench escarpments where excavation would be easy and the situation for filling and emptying the silo favorable.

Native redtop hay would have sold at Anchorage for about $40 to $50 per ton in 1915 and 1916, it is said, but little was offered for sale. Similar hay and also beach-grass hay could have been put up by contract for about $15 to $20 per ton, the writer was told; in other words, this is what the hay would have brought on the ground where cut. Outside hay was selling in 1915 and 1916 for $40 to $60 per ton, and oats for about $60 to $70 per ton. A merchant at Anchorage dealing in feed stuffs gave the following figures on the cost of a ton of oats placed in his warehouse at Anchorage in August, 1916: Cost at Seattle on board ship, $32; freight, $14.50; lighterage at Anchorage, $2.50; handling at Anchorage, $1; drayage at Anchorage, $2; total, $52. The cost to the consumer, with 15 per cent gross profit added, was $59.80 per ton.

GRAIN.

In this country the grains it seems probable will be valuable chiefly for hay, since in short seasons, with much cloudy weather about the

[1] Pit Silos. Farmers' Bul. No. 825, U. S. Dept. of Agriculture.

time of ripening, as often happens, the grain frequently does not mature, at least most of the varieties that have been tried have not generally matured, or else the grain has been cut green for hay. It is true that the grains have been grown primarily for hay, and for this use they are preferably cut in the milk stage. With greater effort to seed earlier and to seed only the earliest varieties, it is possible that all the small grains could be satisfactorily matured, at least in the best years. Barley of an early variety secured from the experiment station at Fairbanks has matured for several successive years, from the original seed, near Knik, and oats have matured.

Not so many attempts have been made to grow wheat. Rye has been tried in a small way, but it does not seem to do as well as oats and barley. Volunteer rye was noticed along upper Cook Inlet in fields where rye had been seeded the year before, showing that at least some seed had matured.

As yet the growing of grain is in an experimental stage, so far as producing the crop for human consumption. It may be possible to produce wheat for flour here from the earliest varieties, some such varieties as the Siberian wheats now being tried at the Rampart and Fairbanks experiment stations; but with the knowledge available it is impossible to say whether or not it is going to be practicable to produce flour from home-grown grain. Even if successful varieties should be obtained, it may still be found more economical to import breadstuffs from Canadian and other ports to the south. There is no doubt, however, about growing barley. It is believed that this crop can be produced profitably, especially for hog and poultry feed. Early planting must be resorted to, if it is desired to mature grain.

OTHER CROPS.

Among other crops that have been tried in the Cook Inlet region and found to be at least partially successful are flax and buckwheat. This year (1916) seed was ripened from both of these crops along upper Cook Inlet. The fields that came under the observation of the writer indicated that these are crops of some promise. They should be thoroughly tested in an experimental way.

Sugar beets are being tried also. The roots were rather small in the one field seen by the writer, but this may have been due to lateness of planting or to the late season. The crop is worthy of thorough trial, particularly with applications of fish scrap, kelp, or barnyard manure.

STOCK RAISING AND DAIRYING.

Dairying and the raising of beef cattle appear to be the most promising means of bringing about the fullest development of agriculture in this part of Alaska. It has been shown conclusively that cattle can

be raised here and that milk, butter, and cheese can be produced successfully with locally grown feed. Apparently it is only by raising stock that the vast quantity of native grass can be utilized; for it does not appear that so bulky a product as hay could be shipped to outside markets with much profit. It is true that some of it can be used for the horses and dairy cattle in this and neighboring portions of Alaska, but this would take but a relatively small part of the hay that can easily be made available, and no part of the enormous quantity that grows on slopes too steep to mow and usable only for pasturage.

Those who can see little or nothing in the agricultural possibilities of Alaska say that this is not a stock-raising or dairying country. Statements of this kind are generally heard, in so far as the experience of the writer goes, from those who have given little serious thought to the subject or who have not traveled far from steamboat landings, from those who can not get away from preconceived ideas about Alaska being a vast snow field inhabited by Eskimos and venturesome gold miners, and from those who have had little or no actual experience with these industries either outside or in Alaska.

One hears it said that the winters are too long and severe for raising stock, that the country is too far from our important Pacific ports to export beef or dairy products, and that sufficient feed can not be locally provided for stock.

The facts are as follows: The winters are long, but they are not colder than those of important stock-raising sections in northern United States. (See climatic data on pp. 9 to 30.)[1] Stock must be fed here through the winter. This is also true with much of the stock raised in the United States, although the feeding season here is longer than in the States, or from 5 to 7 months. The feed can be produced abundantly and cheaply. There is already a considerable home market for beef and dairy products; only a small part of the demand is now being supplied by home products. When this demand

[1] In the following table are given the number and value of live stock in two important live-stock counties in Montana, Yellowstone and Custer Counties, where lower winter temperatures are reached than on Kenai Peninsula, and where there is not much difference between the length of the growing season and that of Kenai Peninsula:

Number and value of live stock in Yellowstone and Custer Counties, census 1910.

	Yellowstone County.	Custer County.
	Number.	*Number.*
Cattle	30,267	113,104
Sheep	408,211	502,307
Hogs	6,595	2,307
Horses	12,863	31,704
	Dollars.	*Dollars.*
Value of live stock	4,459,254	8,318,710
Value of live stock sold or slaughtered	2,214,057	1,633,039

is met it is possible that the mining of coal and other minerals will have attracted a larger population, and when this increased population is supplied with meat from Alaska farms, it may then be found profitable to export beef, tinned beef products, butter, and cheese, just as does Finland, a country that is very similar to Alaska in climate and products. It is possible, of course, that the Alaska rancher may have to be satisfied with smaller profits than the cattle and dairy farmers who have longer growing seasons.

A small herd of cattle has been maintained at Ninilchik for generations. (Pl. XXV, fig. 1.) There are now about 25 head of cattle, mostly cows, at this little village that are said to be the progeny of a herd that was brought to Alaska by the Russians more than a hundred years ago. These are not large cattle, but they are said to be good milkers. Occasionally calves and steers from this herd are slaughtered and used locally or sold at the canneries. Several head from this village were sold at Anchorage in 1915. At Kenai there are 12 cows, including Jerseys, mixed Jersey and native cattle, and one or two native cows. (Pl. XXV, fig. 2.) Homesteaders keep cattle at several other places on the Kenai lowland, on Kachemak Bay, and near Anchor Point. Some are also kept at Kasilof. It is said that seven home-raised beeves were killed by homesteaders near Anchor Point in 1916 and sold to the canneries. All these cattle are maintained exclusively on native pasturage and home-grown feed.

The dairy near Seward had in August, 1916, 11 cows, 3 calves, and 1 bull (Guernsey, Jersey, Holstein, and grades of these breeds) maintained upon pasturage, locally produced hay and ensilage, and some imported feed. This dairy (Pl. XXVI, figs. 1 and 2) sells cream at Seward for $1 a quart and butter at 40 cents per pound. The dairies about the new town of Anchorage, where the cows have so far been kept on pasturage and imported feed, sell milk at 25 cents per quart or 12 quarts for $2.50. Canned milk sells here for 10 cents per 1-pint can.

Feeding of cattle in the Kenai lowlands may become necessary early in October, though in some years not until December, and continues until April or May, or soon after snow disappears, the grass springing up immediately. The cows are frequently turned out to exercise and browse during this feeding period. In the winter of 1914–15 near Bluff Point, on Kachemak Bay, a native cow was kept in the barn and fed only 10 days.

At the Kenai experiment station, where work was begun in 1899 and continued until 1908, Galloway cattle proved to be well adapted to the climate. Concerning the general feasibility of dairying in this part of Alaska a report[1] of this station states:

[1] Annual Report, Alaska, Agr. Expt. Sta., 1908, pp. 20–21.

* * * It was proved that cattle can be reared in that location [Kenai], and that butter and cheese of good quality can be made from the milk of cattle kept there. A small herd was maintained exclusively on native pasture and on feed produced on the station for several years. * * * Fourth, it was proved that hay can be made not only from the native grass, * * * but that grain hay can be made in abundance with certainty and success every year. For this purpose oats were seeded in the early spring and cut for hay when in the milk stage.

A cow at this station, fed on native grass only, gave 2,530 pounds of milk in a period of 87 days in 1902 (June 6 to Aug. 31, inclusive), or an average of about 29 pounds a day.[1]

The writer was told at Ninilchik that the best milker (a grade) of the herd there in 1916 gave 5 pails of milk per day, while the native cows gave from 1 to 3 pails per day, estimated at about 8 pounds per pail.

The milk is of good quality; the native grasses do not impart any noticeable flavor to milk. To quote from a station report:[2]

The absence of bad flavors from the milk at all times is of great importance to the dairy industry. This refers not only to the freshly drawn milk, but also to that which has been kept standing for several days, which undergoes no change except that of lactic-acid fermentation. * * * During the whole time of the station's [Kenai] work not a single instance of bitter milk, stringy milk, bloody milk, or gassy milk, which frequently causes trouble to dairymen in the States, was noticed. These results, no doubt, are due to the practical absence of undesirable forms of bacteria, owing to the relatively low temperature of our summers.

In his report on the grazing lands of the south Alaska coast Piper says:[3]

It is possible to raise many times more beef on the Alaska grasslands than the present population there can use. The only other markets available at present are the Pacific coast cities. Whether it will prove profitable to raise beef in Alaska and market it in Seattle and other coast cities remains to be demonstrated. Apparently there is no other outlet for surplus Alaska cattle, but with a sufficiently large supply there seems no reason why in time such a trade shall not be remunerative.

Cattle fatten readily in spring on Alaska grasses, and keep in fine condition till late in the fall. Some Herefords slaughtered at Kodiak in July furnished as fine beef as any I have ever seen or eaten. * * * With such an enormous wealth of grass as southwestern Alaska possesses it is difficult to doubt that it will become a great dairy country. It is doubtful if equally good opportunities for colonies of dairy husbandmen can be found in the United States to-day.

It is believed that dairying and beef raising can best be carried on as industries about which other farming activities, such as the producing of other products, principally potatoes and other vegetables, grain hay, chickens, and hogs, will center. The individual farmers

[1] Annual Report, Alaska Agr. Expt. Sta., 1902, pp. 253–254.
[2] Annual Report, Alaska Agr. Expt. Sta., 1907, p. 73.
[3] Piper, C. V., Annual Report Alaska Agr. Expt. Sta., 1904, p. 279.

can probably keep only small herds, especially where the farms are situated back from the mountain slopes. Near the mountain slopes, where there is more untillable grassland, larger areas can be utilized for pastures. In all cases it very likely will be necessary or advisable to put up ensilage of native or cultivated grasses and forage plants to supplement the grain and native grass hay, and also to store root crops for supplementary feed. It may even be advisable to use occasionally some concentrates.

Another source of stock feed supply that may prove valuable in a supplementary way is the canneries. Fish meal prepared from waste from canneries is known to have a high nutritive value, and properly prepared meal from fish scrap has been successfully used for dairy cows, hogs, and poultry. Thus the United States Department of Agriculture states:[1]

> Dairy cows fed on a ration of fish meal, compared with cows fed on a similar ration in which fish meal was replaced by cottonseed meal, gave a greater yield of milk, but it contained a lower percentage of butter fat. However, the total amount of fat obtained was approximately the same in both cases. There was no detrimental effect on either the milk or butter from feeding the fish meal.

Shelter should be provided for all stock. Good barns and sheds at present can be constructed of the native timber at moderate cost.

Hogs have frequently been raised on Kenai Peninsula with good success. A few hogs were seen at Ninilchik and near Seward, and others were reported by several homesteaders. (Pl. XXVII, fig. 1.) Chester White hogs seen at the dairy near Seward were of exceptionally good quality. They have been maintained by pasturage and feeding with kitchen refuse and skim milk. By growing sufficient barley and such forage crops as potatoes, turnips, clover, peas, and vetch there would seem no reason why enough pork should not be produced, easily and cheaply, to supply the home demand, especially with the growth of dairying and an increased supply of skim milk.

Fish meal from cannery waste could probably be used to advantage for hogs in this region. In experiments conducted by the United States Department of Agriculture[2] the following facts were brought out.

> The pigs which were fed fish meal received it during the growing season at the rate of 0.5 pound per head per day, and during the fattening period they received this meal at the rate of 0.85 pound per head per day. They made greater gains at a less cost than those fed a ration containing tankage as a supplement. The animals relished the fish meal and maintained a thrifty growth, and were never off their feed during the entire time of the test period.

[1] Bul. U. S. Dept. of Agriculture, No. 378: Fish Meal: Its Use as a Stock and Poultry Food, p. 15.

[2] Loc. cit.

Angora goats have been successfully raised in a small way near Seward (Pl. XXVII, fig. 2), and sheep have been raised on Kodiak and other islands not far distant from Kenai Peninsula. It may be possible, where bears are not numerous, to raise both sheep and Angora goats profitably in this region. In reference to sheep raising a report of the agricultural experiment station[1] states:

> Sheep can * * * be successfully reared in this region [Kodiak and Kenai and anywhere along the coast and on the islands where suitable pasture can be found], but only the long-wooled breeds should be selected. The short-wooled breeds, especially the Merinos, are not adapted to the climate. It rains often. The close short wool holds the water like a sponge. * * * The long-wooled breeds, on the other hand, shed the rain, and they are, moreover, heavier boned and have sturdier constitutions. There is no doubt but that large flocks of long-wooled sheep can be maintained in scores of places throughout the coast region of southwestern Alaska.

No trouble is had in keeping horses. They can be wintered on the native hay, and some have been known to go through winter without feeding or protection. Of course hay is not a complete ration for a horse. Grain hay or some other feed should be supplied. Horses are kept at Hope, Seward, and other points on the peninsula, and at Anchorage.

POULTRY.

Poultry can be raised easily in this region. Some who have had experience with chickens claim that they have had better results here than in the States. There were about 300 locally raised chickens at Ninilchik in the summer of 1916, and others were seen elsewhere on the peninsula. They are said to lay well. Scraps from the kitchen, native grasses, and garden vegetables constitute the principal feed. Home-raised barley and fish meal probably could be used advantageously for chickens. Experiments with fish meal in the proportion of 20 per cent of the weight of the mash used have given good results as chicken feed, the eggs having no taint or flavor of fish.[2]

Locally produced hens' eggs were selling at $1 per dozen at Anchorage in the summer of 1916, when imported cold-storage eggs were selling for 40 to 50 cents per dozen. Ducks and pigeons have been raised here also.

CLEARING LAND.

There are probably no lands on earth with a similar heavy growth of timber that can be cleared easier than the principal agricultural lands of the Cook Inlet region. This is accounted for by the fact that the trees have very shallow root systems which are so weak-

[1] Circular No. 1, Alaska Agr. Expt. Sta., p. 19.
[2] Bul. U. S. Dept. of Agriculture, No. 378, p. 15.

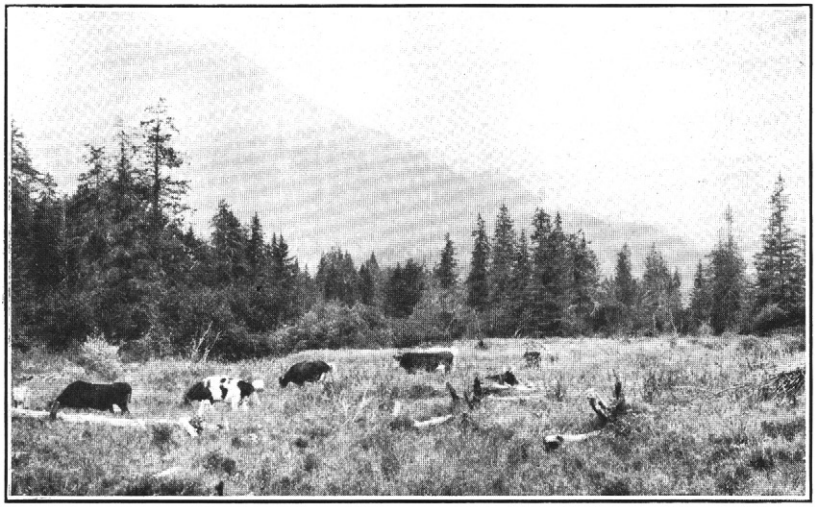
ened when the leaf mold and moss is burned that a large proportion of the trees, often 95 per cent or more, fall, upturning their roots. Thus at one stroke the trees are felled and the stumps are uprooted, leaving only the work of cutting and piling the brush and logs, cutting any roots that may still hold in the ground, and piling the stumps. The valuable timber and firewood can now be hauled off, and in a few weeks the brush and stumps are ready to burn. When the timber is heavy, the cutting and piling, of course, take time, but in comparison with clearing land where the roots penetrate so deeply into the ground that dynamiting, pulling the stumps with machines, and burning with special devices must be resorted to so as to get rid of the stumps, following the laborious work of felling the trees with ax or saw, the clearing of land here is light work indeed.

In one instance it was stated that about 90 hours were required to clear an acre of heavily timbered bench land (deep Knik loam in Matanuska Valley) after burning. Figuring 9 hours to the day, this would give 10 days' labor, which at the prevailing wages would amount to $30 to $50 an acre. In another instance one homesteader states it required about one week to clear 1 acre of lightly timbered bench land (shallow Knik loam on Chester Creek near Anchorage), at a cost of $18 to $30 on a basis of day wages. Here considerable grubbing was necessary, since many of the aspen and birch saplings had not fallen when the ground was burned, as the leaf-mold covering was rather scant. The trees of this part of Alaska are all soft and easy to cut.

As previously stated, there are numerous areas through the Kenai lowlands where fires have destroyed practically all of the timber, so that much of this land is now ready for the plow. In other places dead logs would have to be piled and a later growth of saplings grubbed out. There are, in addition to the burned areas, occasional glades throughout the timbered country that support no trees or bushes, or at most only a few bushes. Here no clearing or only light clearing is necessary.

In case of the stream bottoms, where fires do not cause so many trees to fall and where alder and willow are abundant, much more work is required in clearing land. Stump-pulling machines could be used to advantage in removing the stumps from such land. The heavily timbered bottoms and slopes, like those near Seward, where large hemlock, cottonwood, and spruce, and a dense undergrowth of alder, willow, devil's club, and red-berry elder constitute the growth and where fires do not do so much damage, the clearing is very difficult and expensive.

In the use of fires for clearing land it is not necessary to destroy the timber, since the average fire does not burn the trunks of the



S3720

FIG. 1.—COWS ON RANCH NEAR SEWARD, GRAZING ON REDTOP AND OTHER NATIVE PLANTS.

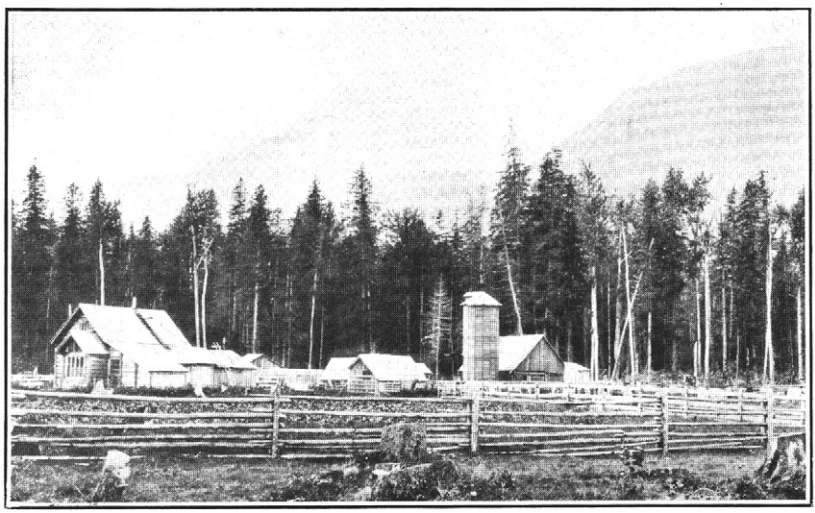
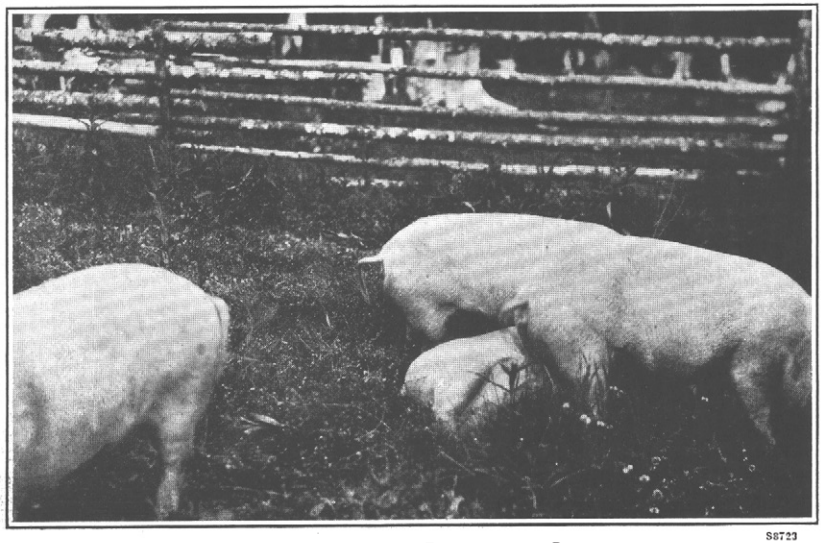


FIG. 2.—DAIRY RANCH NEAR SEWARD.



S8723

FIG. 1.—HOGS ON DAIRY RANCH NEAR SEWARD.

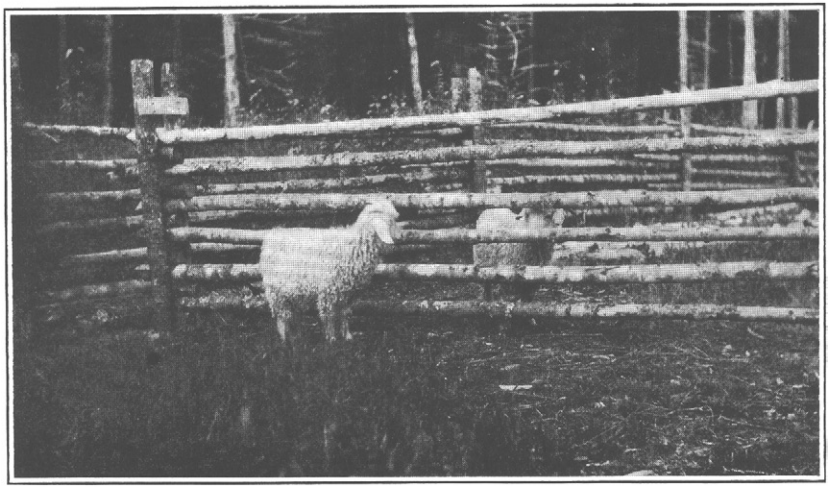


FIG. 2.—ANGORA GOATS, RAISED ON MCPHERSON'S RANCH, SEWARD.

trees, and all the valuable timber can be saved. When the area that it is desired to clear has been burned over, the fires should in all cases be extinguished. Preparation for this should be made before starting the fire by clearing off the leaf mold and moss from a narrow strip surrounding the area to be cleared, unless sufficient hands are available for putting out the fire when it has proceeded to the boundaries.

It is very unfortunate that many homesteaders allow the fires to burn over much more ground than they can use for several years to come, causing large quantities of valuable timber to fall. This fallen timber will be largely wasted in many clearings—allowed to rot or to burn with a second fire. Timber is also being destroyed in clearing off the ground where the trees have fallen by piling and burning. Some restraint should be placed upon these methods, either through governmental supervision or by arousing public opinion against such wastefulness.

PLOWING.

Since there is very little clay in the soils of this region, the various important soil types consisting of friable loams, fine sandy loams, silt loams, and silty clay loams, plowing is very easily performed, if there are not too many stumps of bushes and saplings to root up. One-horse turning plows have generally been used in breaking new ground, but in some instances heavy two-horse turning plows have been employed. If the land is well cleared, efficient cultivation can be accomplished easily with light implements and a single horse. (Pl. XXVIII.)

Owing to the fact that freshly plowed virgin land in this region generally does not give the best results with crops, it is probably advisable to break new ground at least a year before putting in a crop. This gives some time for the improvement of the soil through the ameliorative action of air and freezing. Preliminary plowing should be about 4 to 6 inches deep, it appears, but after this the depth can be increased gradually from year to year. Breaking should take place immediately after summer clearing, since bushes, grasses, and weeds soon appear to make later plowing more difficult. It is not advisable to turn under much moss or leaf mold, since in this cool climate woody, vegetable matter decays with extreme slowness, and if incorporated in the soil makes it too open for the best growth of cultivated crops.

DRAINAGE OF FARM LANDS.

Very little of the better grades of farming land needs artificial drainage. Some level tracts having a deep soil, especially that having a texture as fine as silt loam, probably would be benefited by the construction of an occasional narrow ditch 2 or 3 feet deep.

There are many mucky areas, both on slopes and in depressions, in flats and in stream bottoms, where ditching will be necessary to fit the land for cultivation. Some of the depressions are surrounded by high ground, making it impracticable to construct adequate outlets. It is possible, in such cases, when the area of the land warrants the expense, that outlets into an underlying gravel stratum could be provided by excavating.

To reclaim the Muskeg, extensive canalling and the construction of lateral ditches would be necessary. Work of this kind would be costly, and with the large available area of well-drained land, such reclamation is not at present necessary, except perhaps in some cases where it is desired to control the mosquito or to provide better mowing land.

MANURIAL TREATMENT.

Applications of manure, wood ashes, fish scrap, and kelp have given increased yields of vegetables and grain on the soils of this region. Even the very shallow soil with gravel near the surface has given good yields of vegetables and fair to good yields of grain where manure has been applied. Increased yields of potatoes are reported at Seldovia, where the local kelp was used as a fertilizer. Fish scrap that had been piled and decomposed gave markedly increased yields of potatoes, cabbage, turnips, radishes, and lettuce in a garden of Knik loam on the shore of Skilak Lake this year (1916). Invariably spots where brush has been burned produce plants that are conspicuously better than those in parts of fields where such material has not been burned, indicating need of lime or potash or both.

Stable manure is not only an excellent fertilizer for the soils of this region, but it is one of the very best materials for supplying needed vegetable matter to the soils and to fields that may become impoverished through continuous cultivation, since the organic matter thus supplied is finely divided and in good condition for decaying. It will probably be harmful to plow under coarse, woody vegetable matter, such as coarse grass or moss, because such material, decaying very slowly under local conditions, will leave the soil unfavorably loose. Plowing under green vegetation, such as field peas or clover, likely will be helpful, especially if the soil is well limed. Merely growing these legumes will add nitrogen and thus serve to improve the soil.

Commercial fertilizers have been used only sparingly, and there is little data from which to draw conclusions as to their value. At the Kenai experiment station superphosphate (acid phosphate) was sown broadcast at the rate of 300 pounds an acre on bench loam (Knik loam) and the plot seeded to grain. The results showed a "much more even, uniform, and rank growth, and consequently a heavier yield of grain."

The soils of this region, except in case of the Mud flats, are prevailingly acid, generally very acid both from tests with litmus paper and from analyses to determine lime requirement.[1] It is surprising that so little has been done here in the way of experiments with lime on crops. The writer was unable to find anyone who had given lime a good trial.

From lime-requirement determination made with samples collected by the writer from the Cook Inlet region in 1914, very heavy applications of burnt lime would be required to correct the acidity. It appears that where the productiveness of a soil is increased by continual stirring and aeration, as seems to be true here, additions of lime usually hasten the ameliorative process.

Burnt lime unquestionably is the form in which to apply lime in this region, inasmuch as it is more quickly effective. It is believed that at least 2 tons of good burnt lime per acre should be used; that is, lime that contains 70 per cent or more of calcium or magnesium carbonate or both. It probably will make little difference whether the lime is added in the air-slaked (calcium carbonate) or quicklime (calcium oxide) form; but it would probably be best to apply broadcast and harrow in 2 or 3 inches deep some time before seeding.

It was reported at Seward by one who had applied lime in a garden patch that root maggots had not given any trouble whatever, even with radishes, one of the vegetables most susceptible to injury from this pest. That lime has a deterrent effect upon certain insects, including maggots, in the soil is shown in a recent publication of the Bureau of Entomology.[2]

LOCAL SUPPLY OF FERTILIZING MATERIALS.

Lime.—Limestone occurs in large quantity at Gray Cliff at the entrance to Seldovia Bay. The rock comes down to tidewater, so that it could be readily shipped. Analyses show this rock to run high in carbonates. With plenty of available coal across Kachemak Bay, it should be practicable to produce from this rock lime for both agricultural and constructional use.

The soft whitish limestone about one-quarter of a mile west of the Government railroad at mile 6 out of Seward has been burned in a small way and the product used for plastering at Seward. The analyses show this rock to run high in carbonates. Similar limestones from Snow River near the head of Kenai Lake[3] were analyzed and also found to have a high carbonate content.

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[1] See results of lime requirement determinations made on representative samples of bench soils (Knik) and bottom soils (Susitna) collected in the Cook Inlet region—Soil Reconnoissance in Alaska, Field Operations of the Bureau of Soils, U. S. Dept. of Agriculture, 1914, p. 96.

[2] See Farmers' Bulletin No. 856, U. S. Dept. of Agriculture, p. 10.

[3] Samples collected by Walter Lodge.

In the table below the results of carbonate determination of representative specimens of limestone and of burnt lime are given:

Analyses of limestone and burnt lime from Kenai Peninsula.

Sample No.	Location of sample.	$CaCO_3$ (calculated from CO_2).
		Per cent.
590259	Burnt lime from mile 6 out of Seward	86.07
590260	Limestone from mile 6 out of Seward	96.05
590261	Limestone from Snow River	98.41
590262(a)	Limestone from Seldovia Bay [1]	105.09
590262(b)	do	100.43
590262(c)	do	85.11
590262(d)	do	106.86
590262(e)	do	105.18

[1] Samples from Seldovia Bay represent different strata. Where the calcium carbonate calculation from CO_2 is greater than 100, magnesium carbonate is present.

These analyses show that any of this limestone will make high-grade lime for use in agriculture and probably also for use in the mechanic arts.

Potash.—Potash can be secured from the kelp which grows so plentifully along the Alaskan coast. (Pl. XXIX.) A number of thrifty kelp groves were seen in Kachemak Bay. At Seldovia tons of it can be gathered along the beach, at least in late summer and autumn. This material could be dried and ground for use, but it may be better to burn it and use the ash, as the ash will carry the potash in a more concentrated form.

This kelp contains a high percentage of potash.[1] Probably the supply along lower Cook Inlet and near-by waters would meet the demand for the soils of this region if the harvest were properly regulated so that the beds would not be destroyed.

Cannery waste.—Enormous quantities of fish refuse are annually wasted at the Alaskan canneries, many thousands of tons being turned into the water. Turrentine in 1913 estimated the annual waste in Alaska at 69,570 tons, of which 11,620 tons represented waste of the central coast of Alaska.[2]

This material is capable of being converted into a valuable nitrogenous fertilizer,[1] and the waste from these canneries, several of which are located on Cook Inlet, is far more than sufficient to make all the nitrogenous fertilizer that may be needed through the Cook Inlet region. Some attempt has been made to utilize this scrap for oil, fertilizer, and stock feed in southeastern Alaska. A small plant was installed in the cannery at Klawak in 1913. In 1914 an independent plant was built at Ward Cove, a few miles from Ketchikan. Bower

[1] See Report No. 100, Office of the Secretary, U. S. Dept. of Agriculture: Potash from Kelp.

[2] Bul. No. 150, Bureau of Soils, U. S. Dept. of Agriculture: Utilization of the Fish Waste of the Pacific Coast for the Manufacture of Fertilizer.

and Aller,[1] in a report issued by the Bureau of Fisheries, make the following statement in regard to this plant:

> On account of a late start, * * * this company did comparatively little in 1914, but in 1915 operations were conducted along extensive lines. The plant was enlarged in 1915, and it is understood that it is now capable of handling approximately 200 tons of raw material each day. All of the products manufactured by this company in 1915 were from salmon cannery offal exclusively. This plant is centrally located in a district where within a radius of 50 miles there are about 20 salmon canneries. Contracts have been entered into with a number of these canneries, and the refuse or gurry is saved and transported by the by-products company to its plant at Ward Cove. The advantage of this to the cannery man seems obvious, as there is not only a financial return, but at the same time sanitary conditions around the canneries are improved. Ordinarily the practice is to allow the waste parts of the fish from the cannery process to pass through the floor into the water under the cannery, for most of the canneries are built on piles at the water's edge, or just within the shore line.

FURS.

Considerable fur is taken annually in the Kenai Peninsula and neighboring territory, there being a few men in most localities who devote part or all of the winter to trapping. These men have cabins in isolated parts of the region from which they carry on their operations.

The principal fur-bearing animals of the region are the fox (black, silver-gray, red, and cross), muskrat, mink, weasel (ermine), marten (American sable), lynx, and black and brown bear. The beaver and wolverine are less plentiful and the land otter is only occasionally taken. It appears that the sea otter has been practically exterminated here. Rabbits are usually abundant, though few were seen on the peninsula during the summer of 1916.

Trappers state that the fur-bearing animals of the region have not decreased within the last few years. In some years rabbits are scarce, apparently owing to disease, and when the rabbits are scarce, the lynx seems to migrate to other sections where rabbits, its principal food, are more plentiful.

At the present time there is a close season on marten until November 15, 1921; on sea otter until November 1, 1920; and on beaver until November 1, 1918. The open season for land otter and mink is November 16 to April 1; on weasel, November 16 to March 15; muskrat, December 1 to June 1; lynx, November 16 to March 1; fox, November 16 to March 1; and brown bear (south of parallel 62°), October 1 to July 2. There is no close season for black bear, wolf, wolverine, ground squirrel, and rabbit. Under regulations issued by the Secre-

[1] Bower, Ward T., and Aller, Henry D., Alaska Fisheries and Fur Industries in 1915, Appendix III to the Report of the U. S. Commission of Fisheries for 1915, Bureau of Fisheries, Dept. of Commerce, p. 45.

tary of Commerce "it is unlawful to use a 'klips' trap, a steel bear trap, or any trap having a spread exceeding 8 inches; to kill any fur-bearing animal with strychnine or other poison; to trap protected fur animals at any time when the skin or pelt is not prime; to have in possession or sell or export unprime skins (such skins subject to confiscation). Shipments of furs must be reported to the Bureau of Fisheries, Department of Commerce, on blanks provided for that purpose."[1]

There is much activity on Kenai Peninsula in raising foxes. The breeding animals are captured and kept in wire inclosures, with careful feeding and protection. They are fed meat of the porcupine, rabbit, various birds, fish, and baluga whale. At the fox farm on Anchor Point 30 young black foxes are said to have been raised this year (1916), bringing the total number of blacks on this farm to 60. There are other fox farms on Kachemak Bay and Kenai River, but the number of foxes on these is much smaller.

Good black fox pelts bring from about $500 to $1,000 each. Silver grays, which are rarer, bring still higher prices. If the present widespread fashion of wearing furs in summer as well as winter continues, the trapping and fur-farming[2] industries are likely to become increasingly active.

GAME.

Kenai Peninsula is said to be the best hunting ground for moose in the world. Brown and black bear are also numerous here, and there are many herds of white mountain sheep. The mountain goat is said to inhabit the eastern part of the peninsula. At one time there were caribou on the peninsula (the writer saw caribou antlers in the mountains near the head of Skilak Lake in 1916), but it is said these have disappeared. Wolves, plentiful at one time, were exterminated by poison some years since. The small game consists of rabbits and birds. There were very few rabbits here in the summer of 1916, but their carcasses were plentiful in many places. It appears that they suffer severely at intervals from contagious diseases.

It is estimated by guides and game wardens familiar with the region that there are 5,000 moose on the peninsula. Most of these are found on the western or lowland side, being most abundant between and around Skilak and Tustumena Lakes. During August,

[1] Laws relating to Fur-Bearing Animals, 1916, Farmers' Bulletin, U. S. Dept. of Agriculture, No. 783. For information concerning the killing of fur-bearing animals raised in captivity see Regulations for the Protection of Fur-Bearing Animals in Alaska, Dept. of Commerce, Office of Secretary, 1916.

[2] For further discussion of fur farming, see Farmers' Bulletin No. 328, U. S. Dept. of Agriculture, Silver Fox Farming; also Fur Farming in Canada, second edition, Commission of Conservation, Committee on Fisheries, Game, and Fur-Bearing Animals, Ottawa, Canada, 1914.

1916, our reconnoissance party saw from 5 to 30 moose a day in the Skilak-Tustumena Lakes section during a period of about two weeks. These were seen singly, in pairs, and as cows accompanied by one or two calves. This was just before the rutting season, at which time the cows and bulls congregate in herds, and are seen in much larger numbers than at other seasons. Many carcasses were seen, which appeared to be those of moose that had starved in winter. In a salt lick near the lower end of Tustumena Lake the remains of a large moose were found which had been torn to pieces by a bear. This moose had bogged in the deep, soft peat (upon which an incrustation of salt had formed at the surface), apparently the preceding spring, and had been unable to extricate itself, probably because it was thin and weak at that time. We were told by homesteaders who had spent the winter on the peninsula that numbers of moose starved during the rather severe winter of 1915–16. In winter the animals are said to become very tame, and to come up to cabins for hay, and frequently to trees that are being cut where they begin browsing among the branches almost as soon as the tree falls. The writer was told by guides who have hunted on the peninsula for many years that they had seen brown bear kill moose calves, and it is reported that dogs at Kenai have been known to kill moose. Large numbers of moose are killed annually by those living on the peninsula. Game wardens estimate that from 300 to 400 are killed annually by the inhabitants of the village of Kenai alone. The moose is killed for food; it constitutes the principal meat of places like Kenai and Ninilchik, and has been largely used by the settlers, homesteaders, and cannery operatives. Much meat is wasted, as in those instances where an animal is killed a considerable distance from trail or river, and in the case of an occasional irresponsible person who kills for a tongue or other choice part. Big game hunters kill a few moose each year, the law limiting the bag to two adult males.

It is estimated by local hunters and guides that about 1,000 moose are killed or die annually on the peninsula, the greater number being killed by man. The same authorities say that about the same number are annually raised and some believe that the moose are gradually increasing on the peninsula. It is generally accepted that the market hunter has been the chief enemy of this animal. An order was issued by the Secretary of Agriculture in September, 1916, temporarily prohibiting the sale of moose meat on Kenai Peninsula.

It is reported that the first moose taken in the Cook Inlet country was one killed on Fire Island in 1871. Inhabitants of the village of Kenai told the writer that the moose began to increase on the peninsula shortly after 1871, but that they were not numerous until about 1890, reaching the maximum in number about 1913. Mr. Andrew Berg, of Kenai, states that many moose died in 1913 from

some disease. He counted 200 moose carcasses, mostly cows, in the fall of 1913, while hunting on the peninsula.

A full-grown moose weighs from about 1,000 to 1,500 pounds, on the hoof, and from 600 to 1,000 pounds, dressed. The cows are lighter. The meat of moose is considered excellent for food, some preferring it to beef.

The moose feeds principally upon the twigs of sapling willow, birch, and aspen. The burned-over areas where these trees are reproducing constitute ideal moose pastures. In many places on the Kenai lowland, there are large areas in which the saplings have been browsed or broken down by moose to a uniform height of about 6 feet. It is possible that the reported cases of winter starvation are due to deep snows and consequent difficulty of traveling from an area exhausted of its moose feed to a remote locality where the browsing is better. There is much less feed within reach of the animals in the areas of heavy forest than in those where the trees are younger and shorter, as in the burned-over areas and the bodies of small-tree forests.

The bull moose sheds its antlers about the first of the year and soon afterwards a new growth begins. While the horns are in the velvet, the bulls spend most of the time above the timber line, coming down to the timbered lands in July or August, after the horns have begun to harden. All the bull moose seen on the peninsula during the period August 25 to September 4 had well-developed horns, but fragments of their shedding velvet still dangled from the horns of the animals.

The next most important game animal on the peninsula is the mountain sheep. The sheep live in the mountains, going in small bands of 5 or 6 to 50 or more. (Pl. XXX, fig. 1.) Their principal food consists of the various short grasses that flourish above timber line, such as "mountain timothy."

They are most plentiful in the Kenai Mountains from about Kachemak Bay to the upper end of Skilak Lake. At one time they were numerous northward to Turnagain Arm and east of the railroad, but they were largely killed off here during the building of the Alaska Central Railway (later the Alaska Northern, and now owned by the United States) and during the rush days in the Hope-Sunrise placer district. The writer saw in the summer of 1916, during the course of three days, three small bands of sheep in the country about the headwaters of Benjamin Creek, where sheep could be seen a few years since in bands of 40 or more, according to local information. Louis Bell told the author that now there are only 10 or 15 sheep in the Cooper Creek Mountains east of Skilak Lake, in the same country where sheep were abundant when he came to this section in 1910. The same authority reports having seen a herd of

67 sheep, including 12 lambs, near Bear Glacier, on the headwaters of the middle prong of Benjamin Creek in 1909. It is estimated that there are about 2,000 sheep on the peninsula.[1]

At the present time it is said that sheep are plentiful in the rather inaccessible country about the headwaters of Knik River in the Chugach Mountains north of Kenai Peninsula.

It appears that the sheep are decreasing. In the wild country that they inhabit it has been difficult for the limited force of game wardens to prevent the unlawful killing of these animals. The killing of sheep has been temporarily prohibited by the Secretary of Agriculture in the eastern part of Kenai Peninsula, east of longitude 150.° This is the region in which the sheep were practically exterminated by the depredations of railroad constructors and gold miners. Concerning this the governor of Alaska, in his report for the year 1915, says:[2]

> Then came the stampede for gold in the late nineties to the Cook Inlet country. The stampeders settled on the western side of the peninsula, founding the towns of Hope and Sunrise. At one time there were over 1,000 people in the two settlements. The people depended for a meat supply almost wholly on the moose and mountain sheep, and there was a wanton and wasteful killing of these valuable food animals. Indeed, some of the old-timers made it their boast that they killed a moose merely for what they considered the choice part—the tongue—leaving the carcass to go to waste.
>
> The beginning of construction on the Alaska Central Railway in 1903, and continuing until 1906, on which hundreds of men were employed during the greater part of the time, raised havoc with the moose and mountain sheep. Hunters were engaged at all times to keep the various camps along the line of work supplied with moose and sheep meat, it being cheaper than domestic meats shipped from the States. This condition of wanton and excessive killing of the wild game of the country continued with little cessation until the Sixtieth Congress passed certain amendments to the original game law. Now conditions are much improved. The game law, as applied to moose and mountain sheep, gives them immunity from needless slaughter, with the result that a gradual increase in their number is manifest. Without the restraining effect of the game law, these fine game animals would by this time be practically extinct as far as the Kenai Peninsula is concerned.

From the information gathered by the writer and others of the reconnoissance party it is evident that game conditions have improved, in the case of the moose in particular, but there is still considerable wasteful killing of moose, and it appears that the sheep are decreasing. In the summer of 1916 we saw very few sheep in that portion of the Kenai Mountains just south of the head of Skilak Lake, where our packers and others who had resided on the peninsula for several years, living close to the game country, and who had served as game wardens and guides, said sheep were plentiful a few

[1] Report of the Governor of Alaska on the Alaska Game Laws, 1915, p. 5.
[2] Idem, p. 4.

years ago. We saw the remains of sheep and heard many accounts of the large herds that once were easily approached in this same section. It is believed that within a few years it will be necessary to close the southern part of the peninsula to the hunter, if the sheep are to be protected. This, however, may be unnecessary if a larger force of game wardens can be maintained and market hunting abolished.

Eagles are said to be the most destructive enemy of the lambs. Raven and lynx are also said to kill some of the young sheep, but the market hunter has been the most formidable and merciless enemy of this beautiful animal.

The rams, when full grown, are said to weigh about 175 pounds. The meat is considered the best of all Alaska game, and the heads are highly prized as trophies. A few big-game hunters visit this region annually. The bag is limited to three.

There are said to be some mountain goats in the northeastern part of the peninsula. The habits of the mountain goat seem to be very similar to those of the mountain sheep. Instances are reported where the meat of the mountain goat has been sold in restaurants at Seward for sheep, but there is said to be a distinct difference in the flavor of the two kinds of meat which is readily distinguishable by an experienced person. There appears to be no reason why the mountain goat should not be given the same protection as mountain sheep.

Both the brown (Kodiak) and black bear are numerous on the peninsula. The former is said not to be so plentiful, however, as on the west side of Cook Inlet. Within four days four brown bears were seen by the writer near Skilak Lake, and others were seen by members of the party, while their spoor was in evidence throughout the peninsula. The bears roam the lowlands and mountains throughout summer and fall, beginning their hibernation in late October and November. They feed upon wild berries, showing a special fondness for blueberries and moss berries, upon porcupines and fish, and to some extent upon young moose and the carcasses of older moose. It is said that they are unable to kill mountain sheep and goats on account of the wonderful alertness and agility of these animals. It is also improbable that they kill many adult moose, since that animal, also, is swift. Bears may kill some of the older moose in spring when weakened by the severities of winter. Walter Lodge, of Roosevelt Station, reports having seen in the fall of 1915 the carcass of a full-grown moose which had been freshly killed by a brown bear and covered with moss. The bear was seen about 80 feet from the carcass. He also saw in the spring of 1916, in the upper Chickaloon River country, four moose calves that had been killed.

The brown bear is an extremely dangerous animal under certain conditions, as when wounded or when confronted suddenly. The she bear with cubs is especially dangerous. Men are occasionally killed by brown bears, and in nearly every locality there are one or more who have been disfigured in encounters with this fiercest and largest of the bear family. In November, 1914, a man (Peterson) was killed by a brown bear on Chickaloon River, and in 1915 another (King Thurman) lost his life near the headwaters of the Chickaloon in an encounter with the same animal. Thurman left Kenai Lake in the fall to trap during the winter. His dog returned some weeks later, which aroused the suspicion of an accident; several hunting parties searched for him during the winter, but his body was not found until the following spring. He had left a note stating that a brown bear had mortally wounded him. Although the brown bear ordinarily retreats at sight of man, its habit of occasional viciousness makes it a wise precaution for the traveler to carry a high-power rifle and to keep on the lookout. The smaller black bear has a reputation of being harmless.

The brown bear very likely would do some damage to stock if this industry should develop here extensively. On Kodiak Island both cows and sheep have been killed by it.[1] The bear would retreat to wilder country before the advancement of settlement, although one might make an occasional destructive sally from the back country upon cattle, hogs, or sheep. With a revision of the game law, permitting the killing of the brown bear throughout the year in those sections where it may become a menace to stock raising, such depredations very likely could be handled effectively. At the present time the brown bear is protected south of parallel 62° between July 2 and October 1, which takes up most of the possible hunting season, since the period of hibernation is long. Some of the large brown bears are said to weigh 1,600 to 1,800 pounds. The writer saw one on Benjamin Creek in the summer of 1916 that weighed fully 1,200 pounds, according to the estimates of experienced hunters in the party. The brown bear of the Kenai Peninsula is one of several distinct species of this animal found in Alaska, according to the investigations of the Biological Survey.

Of the game birds, grouse (spruce chickens) are found in the timber and willow, and rock ptarmigan near and above timber line (in summer). Very few ptarmigan and not a single grouse were seen on the peninsula by the reconnoissance party in 1916. The few ptarmigan seen were being pursued by hawks, their most destructive enemy. The scarcity of these birds may have been due to the severity of the preceding winter or to unusual depredations by hawks and

[1] Circular No. 1, Alaska Agr. Expt. Sta., p. 20.

other enemies. In 1915 the writer saw many grouse and ptarmigan in the Susitna Valley.

In summer large numbers of waterfowl, including ducks, geese, brant, snipe, curlew, and plover, visit the region.

The game of the Kenai Peninsula is a very valuable resource, and if properly protected will continue to be so. For years the region has been widely known as affording excellent big-game hunting, and sportsmen have yearly hunted here for moose, sheep, and bear, giving employment to guides (hunters on Kenai Peninsula are required by law to be accompanied by licensed guides) and packers, and trade to the local merchants. Each hunter is permitted to kill in one season 2 adult male moose, 3 brown bears, 3 mountain sheep, and in one day to kill 25 grouse or ptarmigan or 25 shore birds or waterfowl. It is believed that it would be well to reduce the number of sheep allowed killed in a single season from 3 to 2.

Game laws are in force for the protection of both game animals and game birds. In a thinly settled region the size of this, the violations of game laws can not in all cases easily be prevented, especially with the small force of game wardens now employed.[1]

A healthy, determined public sentiment backing up and supporting the game laws would give much assistance toward the suppression of unlawful, unsportsmanlike, and destructive treatment of the country's valuable game assets. It is not meant by what has been said that there is any general tendency among the people to violate the game laws, for this is not the case, at least as regards willful and gross violations. The principal trouble comes from shiftless, irresponsible persons who kill for gain, those who seem by nature intolerant of laws created for the protection of wild things, and a few thoughtless huntsmen.

BIRDS AND ANIMALS OTHER THAN GAME.

The most common nongame birds seen on Kenai Peninsula by the writer are the owl, hawk, Alaska bald eagle, sparrow, the "one-two-three bird" (a very common Alaska summer bird, one of the sparrows that whistles three plaintive notes), northern raven, blackbird, woodpecker, magpie or camp-robber, cormorant, horned puffin, sandpiper, gull, and loon.[2] We heard the song of robins several times in the Kenai lowlands, but did not see one of these birds.

Among the common small animals are the Hudson Bay red squirrel, ground squirrel (or chipmunk), hoary marmot ("whistler" or "whistling pig"), Dawson red-backed mouse, Kodiak vole, Alaska

[1] For further discussion of this subject, see Report of the Governor of Alaska on the Alaska Game Law, 1915.

[2] See North American Fauna, Bul. No. 21, Bureau of Biological Survey, U. S. Dept. of Agriculture, and Smithsonian Miscellaneous Collections: A list of the birds observed in Alaska and northeastern Siberia during the summer of 1914, vol. 66, No. 2.

mountain vole, Alaska porcupine, and shrew.[1] Black, red, silver-gray, and cross-fox, lynx, marten, muskrat, wolverine, mink, and weasel are also found here.

INSECTS.

Mosquitoes are plentiful everywhere in spring and the first part of summer, but are most abundant on the mud flats and in the woods. They are much less common in clearings and burned areas. They are so abundant in many places during the day and until 10 or 11 o'clock at night that it is necessary to wear head nets and gloves to have any comfort. In August they disappear rapidly, few being left generally by the last of the month.

When the mosquito disappears the "whitestocking" (a gnat with white legs) appears in places in such abundance as to require the use of head nets and gloves. Another very small black gnat (the "no-see-um") is troublesome in some localities during late summer. Blowflies, horseflies ("moose flies"), and another small, dark-colored fly are fairly numerous, gathering quickly in large numbers about any exposed meat.

FISH.

The waters surrounding Kenai Peninsula abound with fish. The most valuable of these are the salmon, including five species, as follows: (1) Red or sockeye; (2) silver or coho ("medium red" is the trade name for the canned silver); (3) humpback—"humpies" or pink; (4) king—spring or chinook; and (5) chum—keta or dog. During the spawning season the salmon run up nearly every stream in great numbers. The latter part of August, 1916, we saw the lower Russian River so filled with salmon, which had turned red in their hard fight up the swift Kenai River, that the water appeared thickly speckled with red. This spawning journey upstream represents the closing chapter in the life history of all these five species. Many of them are badly diseased with fungus growths before they reach the spawning ground along the upper sources of the streams, and the brilliant red hue assumed by the fish on their spawning trip is evidence of decadence. Probably many of them perish before spawning, failing to overcome the obstacles of swift water, fungus diseases, and the depredations of gulls, which birds peck out the eyes of the fish as they flounder over shallow riffles. The fish are finally swept downstream dead and dying by the thousands. In many places the stench of salmon which had died as a result of their journey upstream and were piled on bars and against the banks of streams was almost unbearable.

[1] See North American Fauna, Bul. No. 21, Bureau of Biological Survey, U. S. Dept. of Agriculture.

The salmon-canning industry, which is widely distributed along the coast from southeastern Alaska to Bristol Bay, in the southeastern part of Bering Sea, has attained enormous proportions, producing, it is said, about half the world's supply of salmon. The pack in Alaska in 1915 amounted to 4,500,293 cases of forty-eight 1-pound cans each, valued at $18,653,015. In addition, the mild-cured (lightly salted salmon kept at low temperature until marketed, often lightly smoked), pickled (pickled in brine), fresh, frozen, dry-salted, dried salmon, and smoked backs for that year were valued at $561,130. The total catch was 127,074,488 fish. Of the output of canned salmon, 632,848 cases were packed by canneries in central Alaska;[1] that is, "the region on the Pacific from Yakutat Bay westward, including Prince William Sound, Cook Inlet, and Chignik."

The Bureau of Fisheries estimates that the total output of salmon on the Pacific coast of North America for the year 1915 was 421,760,000 pounds, and that of this Alaska produced approximately 229,560,000 pounds. The salmon fisheries of Siberia have been of increasing importance in recent years, but their output is small as compared with the North American pack.

There are 6 canneries on Cook Inlet, 1 at Goose Bay on Knik Arm, 2 at Kenai,[2] 1 at Seldovia, 1 at Kasilof, and 1 at Port Graham. Many large traps constructed of piling, with long netted leads, are annually put in along the shores of Cook Inlet, and there are also numerous gill nets along the shore. The catch of salmon here is large, and the industry a very important one, giving employment in summer to many laborers in the canneries and to boatmen and fishermen. Many of the laborers in the canneries are brought in from the States in summer and carried back in the fall, although a considerable number of native Indians are employed. In 1915, 3,872 persons, including 728 natives,[3] were engaged in the fisheries of central Alaska.

There are also a few salmon salteries on Cook Inlet, and much fish is annually used by both Indians and whites for food and for dog feed. During the running season, July and August, nearly every Indian house, and many of those of the whites, has close by a fish shed or drying racks filled with strips of salmon. (Pl. XXX, fig. 2.) Some herring fishing on a commercial scale is done in the fall in Kachemak Bay.

The salmon are delivered from the traps by scows towed by the cannery tenders. Plate XXXI shows a scow unloading its cargo of salmon at the Kasilof cannery.

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[1] Document No. 834, Bureau of Fisheries, Dept. of Commerce: Alaska Fisheries and Fur Industries in 1915.

[2] One of the canneries of Kenai was burned in 1916, but it is being rebuilt.

[3] Document No. 834, Bureau of Fisheries, Dept. of Commerce.

Among the salt-water fish that are caught with the hook and taken in fish traps along with salmon are the halibut, flounder, sole, cod, and trout. These are eaten locally, but are not caught on a commercial scale.

The streams abound with trout and grayling. Russian River has the reputation of being one of the best fishing streams in Alaska. The writer had excellent fishing in this and also in other streams, particularly in Ptarmigan Creek, near the head of Kenai Lake, and in some of the streams near Seward. Dolly Varden and rainbow trout are very numerous. The latter, which is very game, affords excellent sport. These fish follow up the runs of salmon, and are said to destroy large numbers of salmon eggs and young salmon. The lakes also are well stocked with fish. Lake trout are caught with the hook in abundance by those visiting Kenai Lake. On Cook Inlet we had no difficulty in catching sole, flounder, halibut, cod, and ling cod when anchored in such waters as Bear Cove and Seldovia Bay.

In the summer of 1916 a local organization attempted to take beluga whales in Cook Inlet for their skins and oil. The chief difficulty appeared to be in capturing this wary mammal. They are abundant in Cook Inlet, their glistening white bodies making a pretty picture on sunny days as they rise at intervals to the surface. The skin is said to be valuable for shoe leather.

Clams are found in several localities on lower Cook Inlet, as, for example, in Seldovia Bay. Crabs are reported in Kachemak Bay, but none were seen here by the writer.

The salmon and other fisheries are governed by laws administered by the Bureau of Fisheries, Department of Commerce. Agents of this bureau visit the canneries and salteries occasionally.

The laws forbid the erection or maintenance of—

> any dam, barricade, fence, trap, fish wheel, or other fixed or stationary obstruction, except for purposes of fish culture, in any of the waters of Alaska at a point where the distance from shore to shore is less than 500 feet or within 500 yards of the mouth of any red-salmon stream where the same is less than 500 feet in width, with the purpose or result of capturing salmon or preventing or impeding their ascent to their spawning grounds, and the Secretary of Commerce is hereby authorized and directed to have any and all such unlawful obstructions removed or destroyed.

It is also—

> unlawful to lay or set any drift net, seine, set net, pound net, trap, or any other fishing appliance for any purpose except for purpose of fish culture, across or above tidewaters of any creek, stream, river, estuary, or lagoon, for a distance greater than one-third the width of such creek, stream, river, estuary, or lagoon, or within 100 yards outside the mouth of any red-salmon stream where the same is less than 500 feet in width. It shall be unlawful to lay or set any seine or net of any kind within 100 yards of any other seine, net, or other fishing appliance which is being or which has been laid or set in any of the waters of Alaska,

or to drive or construct any trap or any other fixed fishing appliance within 600 yards laterally or within 100 yards endwise of any other trap or fixed fishing appliance.

It is—

unlawful to fish for, take, or kill any salmon of any species in any manner or by any means except by rod, spear, or gaff in any of the waters of Alaska over which the United States has jurisdiction, except Cook Inlet, the Delta of Copper River, Bering Sea, and the waters tributary thereto, from 6 o'clock p. m. of Saturday of each week until 6 o'clock a. m. of the Monday following, or to fish for, or catch, or kill in any manner or by any appliances except by rod, spear, or gaff any salmon in any stream of less than 100 yards in width in Alaska between the hours of 6 o'clock in the evening and 6 o'clock in the morning of the following day of each and every day of the week. Throughout the weekly close season herein prescribed the gate, mouth, or tunnel of all stationary and floating traps shall be closed, and 25 feet of the webbing or net of the "heart" of such traps on each side next to the "pots" shall be lifted or lowered in such manner as to permit the free passage of salmon and other fishes.

It is also—

unlawful to can or salt for sale for food any salmon more than 48 hours after it has been killed or for any person, company, or corporation wantonly to waste or destroy salmon or other food fishes taken or caught in any of the waters of Alaska.[1]

Undoubtedly some violations of these laws can not be prevented owing to the great area over which the industry is developed and the time required by the patrol force to visit the various establishments and waters. A well-matured public opinion favorable to the enforcement of the laws intended to protect and perpetuate this immensely valuable asset—the fish of Alaska—would go far toward the attainment of this end. It seems that it would be well for an inspector or fish warden to give his entire time to well-defined fishing areas of a size that would permit more frequent inspection of the streams, canneries, and salteries of such areas of water.

The Secretary of Commerce has the authority to—

set aside any streams or lakes or preserves for spawning grounds, in which fishing may be limited or entirely prohibited; and when, in his judgment, the results of fishing operations in any stream, or off the mouth thereof, indicate that the number of salmon taken is larger than the natural production of salmon in such stream, he is authorized to establish close seasons or to limit or prohibit fishing entirely for one year or more within such stream or within 500 yards of the mouth thereof so as to permit salmon to increase; provided, however, that such power shall be exercised only after all persons interested shall be given a hearing, of which due notice must be given by publication; and when the interested parties are known to the department they shall be personally notified by a notice mailed not less than 30 days previous to such hearing. No order made under this section shall be effective

[1] Laws and Regulations for Protection of Fisheries of Alaska, Department Circular No. 251, Bureau of Fisheries, Alaska Fisheries Service, pp. 2–3, 1916.

FRESHLY PLOWED LAND ON RANCH NEAR ANCHORAGE.

The soil is the shallow Knik loam. It was plowed with a 1-horse plow.

S8809

GIANT KELP, GATHERED NEAR SELDOVIA.

Kelp is abundant in places in Kachemak Bay and elsewhere.

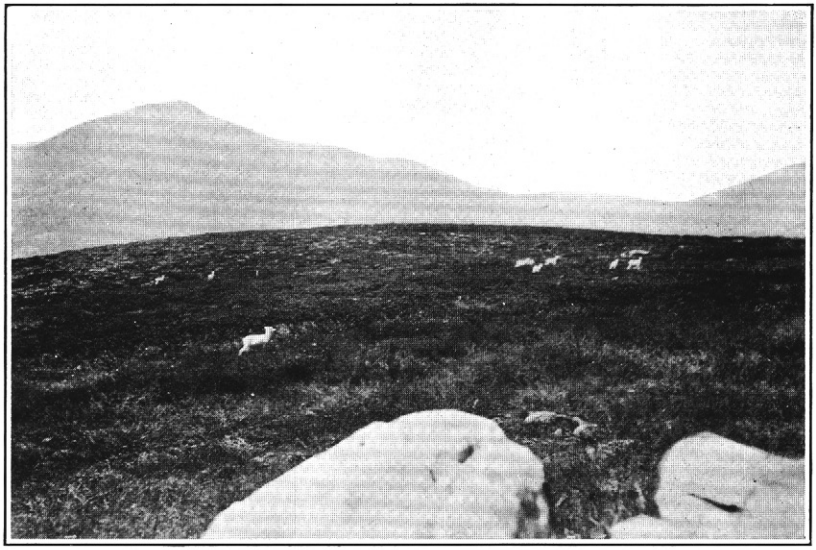
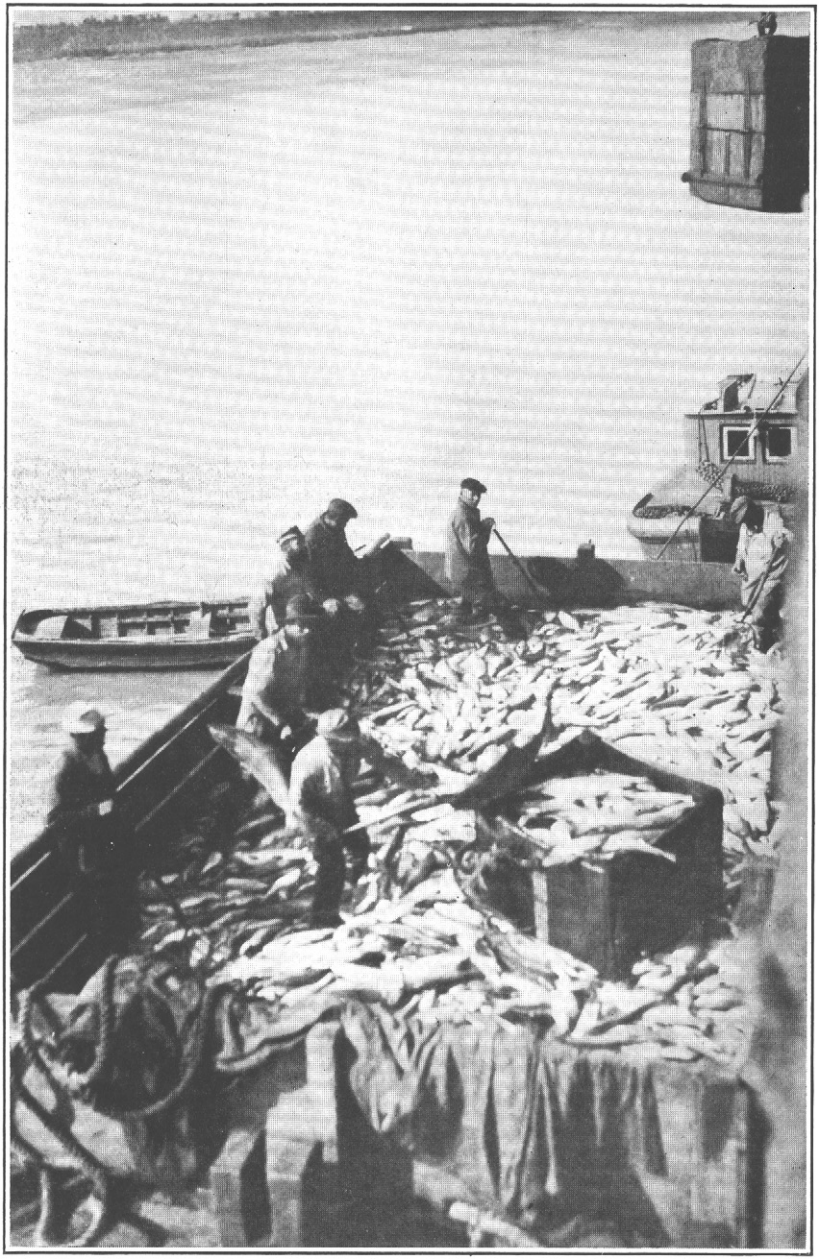


FIG. 1.—MOUNTAIN SHEEP GRAZING ON THE MOUNTAINS OF KENAI PENINSULA.

The sheep find good grazing on the slopes and benches above the timber line. Mountain timothy is one of the principal sheep grasses.

S8808

FIG. 2.—DRYING SALMON AT SELDOVIA.



S8819

UNLOADING SALMON FROM SCOW TOWED IN FROM A TRAP IN COOK INLET. KASILOF CANNERY.

before the next calendar year after same is made; and provided further, that such limitation and prohibition shall not apply to those engaged in catching salmon who keep such streams fully stocked with salmon by artificial propagation.[1]

One of the general regulations relative to the handling of salmon is as follows:

> The canning and preserving of the so-called belly of salmon, which results in the waste of a large proportion of the edible part of the fish, is a wanton waste * * * and those who engage in this practice will be reported for prosecution. * * *[2]

RECREATIONAL AND SCENIC FEATURES OF THE KENAI PENINSULA REGION.

The Kenai Peninsula region, situated on the northernmost part of the Pacific Ocean, possesses in its snow-covered mountain peaks, glaciers, fiords, and lakes scenic features of great interest and offers varied opportunities for exploration, mountain climbing, camping, picture taking, boating, hunting, and fishing. Already a considerable number of tourists visit the region. Most of these, however, make the round trip from Seattle, Vancouver, Prince Rupert, and other Pacific coast ports to Anchorage or Seward, remaining long enough to get but glimpses of the country here and around the other Alaskan ports at which the boats call. A few stay over for a week or more, but as yet very few undertake trips into the mountains and forests except the occasional sportsmen who hunt on Kenai Peninsula and elsewhere.

When the railroad from Seward to Fairbanks is opened, so that visitors may make easy and quick trips across Kenai Peninsula, up the Susitna Valley, and through the Mount McKinley (Mount Denali) region of the Alaska Range into the great Tanana Valley of interior Alaska, it is believed the improved opportunities for travel and camping in this portion of Alaska will attract many more transients and that the same conditions will tempt them to make longer stops, especially when the wonderful natural attractions of the country become better known.

Prince William Sound, with its many islands and great fiords and numerous glaciers, affords splendid opportunities for cruising and exploration and has good hunting and fishing. Its waters are protected from the swells and winds of the Pacific by Hinchinbrook, Montague, Knight, Latouche, and other islands, so that the sound is characteristically smooth, admitting the comfortable and safe use of small motor boats.

The Kenai and adjacent Chugach Mountains and the country about Kenai, Trail, Skilak, Tustumena, and other lakes, and along

[1] Department Circular No. 251, Dept. of Commerce, 1916.
[2] Department Circular No. 251, Dept. of Commerce.

Kenai and Kasilof Rivers are ideal for camping, fishing, and picture taking. Travel is easy above timber line in the mountains of the region, although difficulties may be experienced in getting through the alder thickets that are usually so abundant immediately above timber.

The lakes are placid and beautiful in their setting of mountains and forests. (Pl. XXXII, figs. 1 and 2.) Kenai Lake is surrounded by mountains that rise abruptly from the water along much of the shore line; the eastern or upper end of Skilak Lake extends back into the Kenai Mountains, while its western end reaches out into the lowlands. The rivers are swift and capable of affording excitement to those appreciating boating through rapids. (Pl. XXXIII.) Kenai River, heading in Kenai Lake and flowing westerly through Skilak Lake across the peninsula to Cook Inlet, is frequently navigated downstream by small river boats, which in the hands of expert rivermen safely pass through the numerous rapids.

An immense field of permanent ice and snow extends from the headwaters of Resurrection and Russian Rivers southwesterly for a distance of about 75 miles, occupying the greater part of the Kenai Mountains in this portion of the peninsula. This field is nearly 40 miles across in its widest place; that is, from the lower end of Northwestern Glacier on Harris Bay to the lower end of Tustumena Glacier at the head of Tustumena Lake. On the eastern and southeastern sides of the peninsula a large number of glaciers extend down through the mountain valleys to the edge of the sea. Some have flats or deltas of bowlders, gravel, sand, and silt about their lower ends. Among the principal and most interesting glaciers of the peninsula are Yalik, McCarty, Northwestern, Bear, Kachemak, Dinglestadt, Chernof, Ellsworth, Excelsior, Princeton, Nellie Juan, and Tebenkof. (Pl. XXXIV.) Many glaciers in this region have never been completely explored, so that there are numerous opportunities for valuable, interesting, and probably exciting exploration and mapping.

From any slightly elevated point on Cook Inlet magnificent views of mountain, lowland, and sea may be obtained. Looking in a northerly direction from the south side of the inlet one sees the lofty Alaska Range, with its countless snowy peaks, many of which are unscaled and unnamed. From this range Mount Dall, Mount Russell, Mount Foraker, and Mount McKinley lift their majestic peaks. Mount McKinley, the loftiest peak on the North American Continent, with an altitude of 20,300 feet, has afforded great interest to mountain climbers. This mountain is plainly visible from any point, with unobstructed view, on Kenai Peninsula. It is about 140 miles distant from Anchorage, near the upper end of Cook Inlet, where good views are had of it on any clear day.

Southward from the Alaska Range, flanking the western side of the inlet, is another range of rugged mountains with lofty snow-covered peaks—the Aleutian Range. In this, the peaks of Iliamna and Redoubt, the latter 10,200 feet high, stand near the shore. Iliamna is an active volcano to the extent that steam (or "smoke") issues from it most of the time. Redoubt has had some eruptions that spread ashes over a vast area of the country.

The afterglow (alpenglow) on the snow mountains of the Alaska and Aleutian Ranges is a thing of awe-inspiring beauty. An artist of note who has painted Mount McKinley and other Alaskan scenery told the writer he had found it impossible to paint Mount McKinley when clothed with the rapidly changing colors of autumn afterglow—that when the paint had been quickly mixed for one shade of rose or pink an entirely different shade had spread over the mountain or portions of it before the preceding color could be put on canvas. The sunsets here, too, are of the most wonderful splendor, and the sky and clouds continue to be beautifully colored far into the night, often all night in midsummer. Still another beautiful thing of this northland is the northern lights of autumn and winter.

Aside from the splendid natural scenery, there are other interesting things to see and photograph in this region. On Kenai Peninsula one can get pictures of wild game in their natural abode—pictures of moose, sheep, bears, and porcupines, while sea lions can be easily photographed on the rocks which stand as pinacled islands with their summits high above the sea at the entrance to Resurrection Bay.

The deep coastal indentations of both mainland and islands and the narrow passage between shores of precipitous mountain slopes make much of the country extremely interesting and beautiful, particularly to those who can cruise leisurely along the coasts and among the islands. The fiords and passages of Prince William Sound are probably unexcelled for beauty, even by those of Norway. College Fiord for example, is a deep, narrow arm of the Pacific extending 23 miles from its entrance back into the Chugach Mountains, with steep walls and numerous glaciers along its shores. At the head of one prong of its inland extremity is Howard Glacier, and at the head of the other prong Yale Glacier. By ascending Yale Glacier and crossing over to Meares Glacier, on a connecting glacier, after a trip of about 7 miles over ice, one enters the head of another deep fiord, Unakwik Inlet, which is 17 miles long and not more than 3 miles across the widest place.

THE KNIK ARM STRIP.

North of Chickaloon Bay, on the east side of Knik Arm, which is the northernmost extension of Cook Inlet, there is a strip of lowland

corresponding to the Kenai lowland. This strip is, in fact, an extension of the Kenai lowland and a part of the great Cook Inlet-Susitna plain. It extends from the inlet back to the Chugach Mountains, which here represent the northern extension of the Kenai Mountains. This strip is approximately 15 miles across in the widest place, from Point Campbell to Rabbit Creek; and it narrows northeastward practically to the point of disappearance at Knik River, where the mountains come down very nearly to the water of the arm. Across the arm and the delta of Knik and Matanuska Rivers at this point the same character of land is found, and this continues northeastward up the Matanuska Valley and westward to the Muskeg and lowlands of the Susitna Valley. The area represented in the strip of lowland east of Knik Arm is approximately 59 square miles, exclusive of about 3 miles of mud flats.

This area includes soils like those occurring in the Kenai lowlands; that is, bench lands (Knik soils), stream bottoms (Susitna soils), and Muskeg. It has topographic and drainage features and a geologic history corresponding to the features and geologic history represented in the main portion of the Kenai lowland. It consists of bench lands underlain by gravel, narrow strips of bottom land along the streams that flow across the lowland to the inlet, and a considerable number of areas of Muskeg.

Most of the shore line is marked by steep escarpments between the bench lands and the beach or mud flats, the highest ranging probably from about 40 or 50 feet to 150 feet or more. There are mud flats about the mouths of most of the streams, such as Chester and Ship Creeks, and Eagle (Yukla) River and a large body of mud flats from about the mouth of Peters Creek to beyond the mouth of Eklutna River. The surface varies from level to hillocky, topography of the latter nature being especially characteristic of the country near the foot of the mountains. There are differences in elevation from place to place, in some instances represented by ridges and hills and in others merely by rises through escarpments from one level or nearly level flat or bench to another.

The deepest soil of the prevailing bench land type, Knik loam, is that found in a strip following the outer edge of the lowlands; that is, along Knik Arm and Chickaloon Bay. (See soil map.) Some deep loam occurs between this strip and the mountains, but the greater part of this inner portion of the lowlands consists of the shallow Knik loam, much of it being the type locally known as "G-pole flats." The deeper Knik loam seldom is more than 18 or 20 inches deep (medium-deep Knik loam) over the gravelly material, while the shallow phase ranges from 4 or 5 inches to about 8 or 10 inches. The town of Anchorage is built on a level bench of Knik loam having a depth to gravel of about 8 to 12 or 14 inches.

The deeper soil supports the best timber, consisting mainly of spruce and birch. The best of this has been cut for ties and piling for the Government railroad, at least the best from those areas close to the road. The shallow soil supports, predominantly, either a growth of black spruce, seldom exceeding 6 inches in diameter, or a growth of aspen or mixed aspen, birch, and white spruce, all of small size. The Muskeg is like that of the Kenai lowland (see p. 80) and supports the same vegetation.

The town of Anchorage sprang up at the mouth of Ship Creek immediately after the route of the Government railroad was decided upon by the President and the announcement made that headquarters for work on the Knik Arm-Matanuska division of the road would be at this point. The town now (1916) has an estimated population of between 4,000 and 5,000.

The railroad comes around the north side of Turnagain Arm, crosses the Knik Arm lowland from Potter Creek to Anchorage, then continues through the lowland to Knik River near its mouth, and thence proceeds across this stream and Matanuska River to Matanuska Junction, about a mile north of Matanuska River. From this point one branch swings northeasterly to the coal fields of Matanuska Valley, while another branch turns to the northwest through the Susitna Valley. The Susitna Valley line is to be the main line to Fairbanks.

Owing to the railroad this Knik Arm strip will probably be opened up more rapidly than the Kenai lowland country, but not having as deep a soil as the Matanuska Valley, the strip is not likely to be so fully developed as the Matanuska Valley farming section, at least not at first. The agricultural development here will be more spotted, probably, according to the location of the better soil. If fertilizers can be had cheaply, it may not be impossible to farm successfully even the shallow Knik loam, and upon this possibility much depends in the matter of agricultural development through this area.

GENERAL DEVELOPMENT.

Having about the same climate as the Kenai lowlands, with apparently a little more sunshine and less wind, and the same soils and native vegetation, it follows that the Knik Arm strip is adapted to the same crops. Many parts of the Kenai lowland embrace better soils—deeper soils—than the average of the soil in this strip, but this is a feature that affects yields rather than crops.

A considerable number of homesteaders are growing potatoes, cabbage, turnips, lettuce, and the other vegetables that succeed in the region within the limits of this area. Some of these products are sold at Anchorage and others at the camps along the Government

railroad. There are no large areas as yet in cultivation, probably the largest seen being that at Whitney's ranch, on Ship Creek, where several acres are cropped. Elsewhere comparatively large areas were being prepared for cultivation.

Dairy cows are kept, and some hogs and chickens are raised about Anchorage. Some cows, hogs, and chickens were seen on ranches several miles from Anchorage, as at Whitney's place, which is about 6 miles above the mouth of Ship Creek. The cows and hogs are pastured in summer, but given some feed in addition to that obtained in pasture. In winter they are fed on imported concentrates, native hay, and, in the case of hogs, kitchen refuse.

There is an abundance of native redtop on the mountain slopes near the timber line, and areas of it occur locally through the lowland. There is much good pasturage and hay grass on the higher mud flats, such as that along Knik Arm between Peters and Eklutna Creeks. From some of the Muskeg areas hay has been cut, consisting chiefly of slough grass (*Carex* sp.).

PRINCE WILLIAM SOUND REGION.

GEOGRAPHY.

Prince William Sound lies immediately east of Kenai Peninsula. Its northern extremities—College Fiord, Unakwik Inlet, and Port Valdez—reach back into the Chugach Mountains about 23 to 37 miles north of Point Decision at the entrance to Passage Canal (or Portage Bay), or, in other words, 23 to 37 miles north of the northernmost point of the eastern shore of Kenai Peninsula. The sound extends eastward to the Copper River delta. It is nearly shut off from the Pacific Ocean by Hawkins, Hinchinbrook, Montague, Latouche, Elrington, Hoodoo, and Bainbridge Islands. The distance across from the head of Orca Bay on the east to the head of Port Nellie Juan, or Kings Bay, on the west is about 106 miles; and the distance from the head of College Fiord on the north to the southern extremity of Montague Island on the south is 104 miles. Figure 1 is a map of the general region.

Grant and Higgins[1] thus describe Prince William Sound:

> Prince William Sound is not a sound according to the customary usage of the term, but is an extensive bay or gulf, which includes many islands. The coast line is indented by numerous, long, narrow inlets or fiords and by other less regular embayments whose shores are commonly of great irregularity. The approximate amount of mainland shore line from the Copper River delta to Cape Puget is 975 miles, and the total shore line of the islands in the sound is nearly 1,065 miles, making the total amount of shore line on the sound approximately 2,040 miles. The coast is rugged and rocky and in many places

[1] Grant, U. S., and Higgins, D. F., Bul. No. 443, U. S. Geol. Survey, p. 9.

rises abruptly from the water's edge to altitudes of 1,000 to 3,000 feet. A few miles inland from the coast are mountains from 3,000 to over 10,000 feet in altitude. Mountains uninterruptedly surround the sound on its east, north, and west sides, and the larger islands, especially Hawkins, Hinchinbrook, and Montague, which lie along the south side of the sound, are also mountainous. There are many snow fields about Prince William Sound, and from these fields glaciers descend, reaching tidewater in a number of inlets or fiords on the north and west sides of the sound.

PHYSIOGRAPHY AND GEOLOGY.

By far the greater part of the shore line of both the islands and mainland is marked by steep slopes rising from the edge of the water. There are frequent rocky cliffs and very precipitous rocky slopes. In other words, the sound is nearly surrounded by mountains whose slopes extend down to the sea. The islands themselves very largely are nothing more than mountains that rise out of the sea. There are some low islands, such as Green Island, and low flattish areas, such as the low area at the north of Hinchinbrook Island, known as Strawberry Point, but these are not very extensive.

The physiography of the general region is described by Grant and Higgins as follows:[1]

> As the St. Elias Range extends northwestward from Mount St. Elias it divides into subordinate ranges, the southern one of which is called the Chugach Mountains. West of Copper River the axis of the Chugach Mountains trends a little north of west, runs roughly parallel with the northern shore of Prince William Sound, and then bends suddenly to the southwest and forms the backbone of Kenai Peninsula. The continuation of the same mountains to the southwest is indicated by a few small islands in the entrance to Cook Inlet, and the mountains themselves reappear on Afognak and Kodiak Islands. The Chugach Mountains nearly surround Prince William Sound. In fact, the sound lies in this mountain range, but to the south of its main axis. The sound is thus a highly eroded part of the Chugach Mountains into which the sea has come.
>
> On the south the altitude of the mountain tops is much lower than on the north and northwest, where the highest peaks occur along the axis of the range. About Cordova the mountains are 2,000 to 2,500 feet above sea level; north of Cordova Bay they rise to 3,500 feet or higher. On Elrington and Latouche Islands, at the southwestern entrance to the sound, the mountains rise to about the same altitude (1,500 to 2,000 feet), but they are higher at intermediate points; for example, on Montague Island. The general altitude of the mountains on this island is probably 3,500 to 4,500 feet, but accurate figures are not available. North of Fidalgo Bay the general height of the mountain tops is 2,500 to 3,000 feet; two peaks here which rise higher than the others are Copper Mountain, 3,830 feet, and Mount Denson, 5,886 feet. South of Port Valdez heights of 3,500 to 4,500 feet are common, and north of Port Valdez altitudes of 4,500 to 6,000 feet are reached. Still farther north, along the main axis of the range, elevations of over 7,000 feet are reported. Still higher peaks along this axis are known; one about 30 miles north of the tidewater terminus of the Columbia Glacier rises to 11,190 feet, and three peaks which are 7,500 to 8,200 feet in height occur between the heads of Harriman

[1] Grant, U. S., and Higgins, D. F., Bul. No. 443, U. S. Geol. Survey, pp. 14–17.

Fiord and Passage Canal of Prince William Sound and Turnagain Arm of Cook Inlet. A peak near the west side of College Fiord is 8,046 feet in height; two others, a few miles north of Harriman Fiord, rise to approximately 10,000 feet, and north of these two is at least one still higher peak.

Viewed from the water near their bases these mountains appear very irregular in altitude, but when seen from some high peak or from a distance of 10 miles or more across the water the mountain tops appear to rise to the same general altitude. The fairly accordant tops of these mountains, composed of highly folded strata, thus suggest an ancient peneplain which has been raised far above sea level, warped, and highly eroded. This erosion has been so complete that no extensive remnants of the old peneplain appear about Prince William Sound, and in places, especially in the central part of the sound, all traces of this old surface have disappeared. The warping brought up the peneplain to its highest point along the axis of the Chugach Mountains, from which the old plain slopes southward toward the sea. Minor slopes descend from the east and the west toward the center of the sound.

These accordant mountain tops can be seen to the north of Orca Bay when viewed from the northern part of Latouche Island or from the vicinity of Point Hinchinbrook Island, and are especially marked on Montague Island when viewed from the northern part of Latouche Island or from the vicinity of Point Countess, about 20 miles northwest of Montague Island. On the west side of Port Bainbridge the mountains on the north rise to about 3,000 feet and become lower on the south toward Point Puget, near which they are about 2,000 feet above sea level.

The topography of Prince William Sound is that of a maturely eroded mountainous district with the forms of river erosion modified by ice erosion. Into such a district the sea has come, filling the main basin of the sound and extending far up the valleys that lead into it. The main valleys, when the district was all above sea level, probably ran southward, possibly one to the east and another to the west of Montague Island, while tributary streams came in from the northwest and northeast.

Many of the valleys as they exist to-day are of the fiord type, especially in the northern and northwestern parts of the sound, the fiord character not being so prominent in the eastern part. Among the fiords may be mentioned Port Valdez and Port Wells, the latter with two fiord arms. The main stretch of Port Valdez is about 14 miles in length and 3 miles in width. Its depth is from 600 to more than 800 feet. Soundings in Port Wells are not available. The deepest known part of the sound stretches north-northeast, between Knight and Chenega Islands, from Point Countess toward the entrance to Unakwik Inlet. In this stretch are soundings of more than 1,800 feet, and just east of Long Island one of 2,460 feet has been made.

The relation of some of the valleys to geologic structure is marked. The axis of Port Valdez practically coincides with the strike of the graywackes and slates along its sides, and the depression in which this fiord lies is probably cut in the more easily eroded slates. The main body of Jackpot Bay, west of Chenanga Islands, has cliffs of resistant graywackes along its sides, but the axis of the bay shows outcrops of softer slates, to which the location of the bay is undoubtedly due. The southeastern arm of Port Nellie Juan is also parallel to the strike of the surrounding rocks. Tatitlek Narrows, between Bligh Island and Ellamar, lies in an easily eroded belt of black slates, and the long, narrow island in this passage is composed of a more resistant dike of diabase. Latouche, Elrington, and Hoodoo Islands and the passages between them lie along the general strike of the rocks of these islands. It is quite likely that the long axis

FIG. 1.—A TYPICAL LAKE OF THE KENAI PENINSULA LOWLANDS. THIS LAKE IS NEAR THE EAST FORELAND.

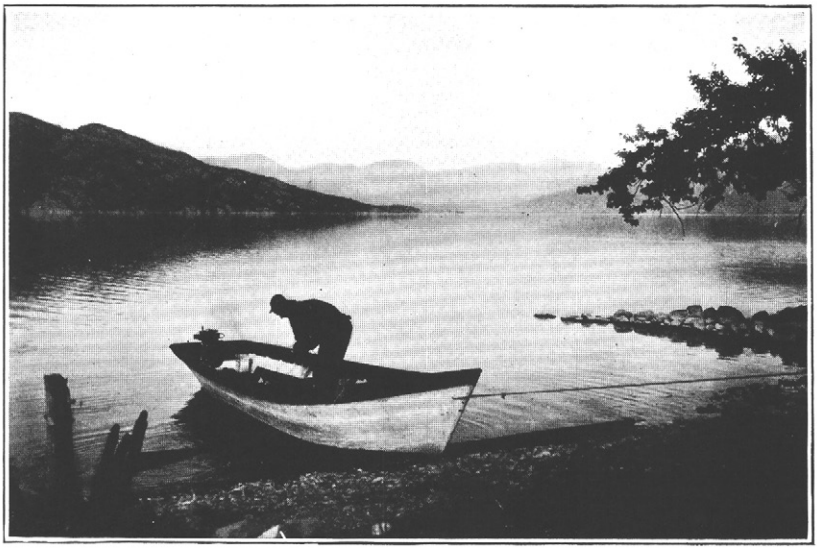
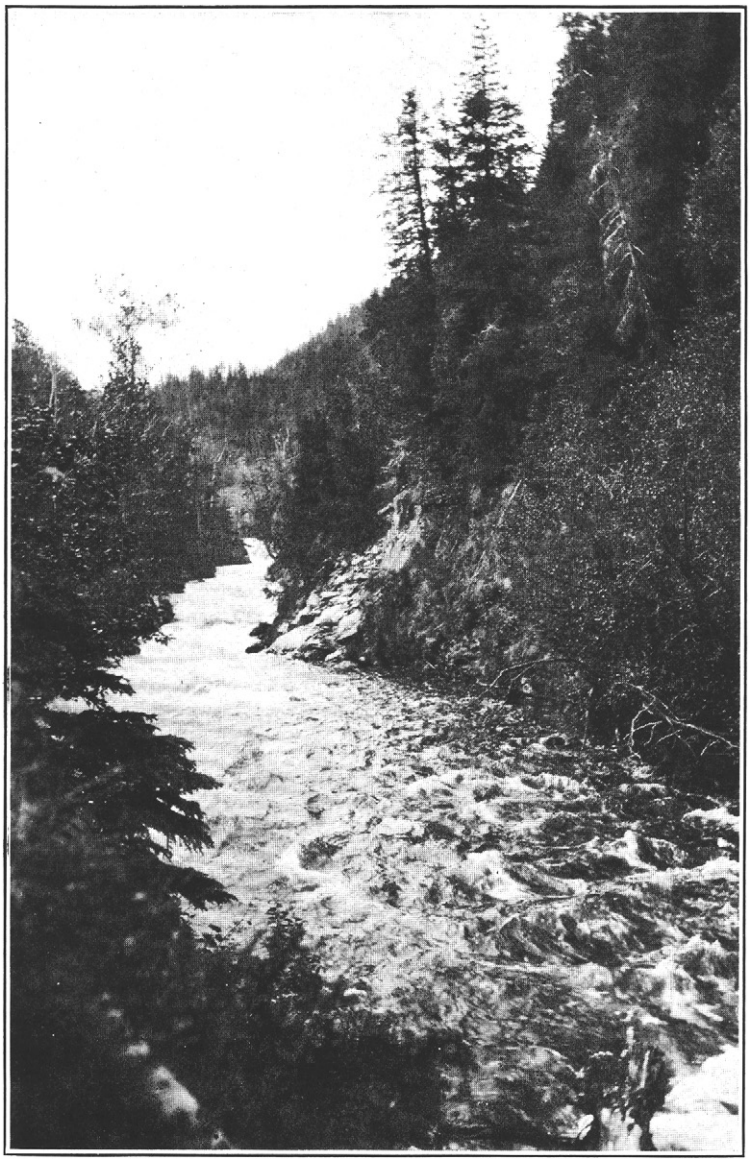
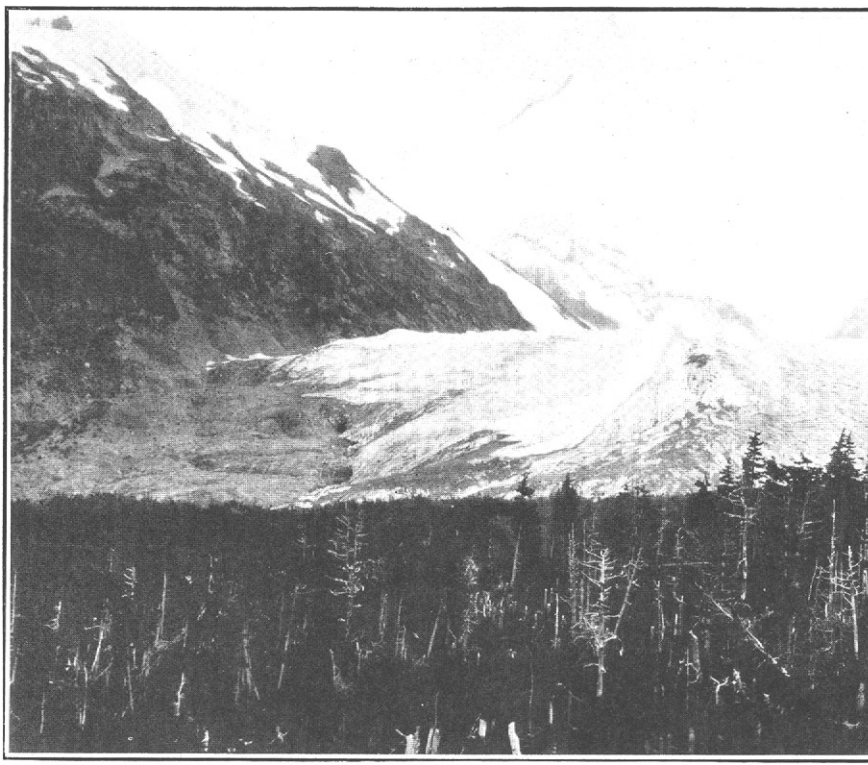


FIG. 2.—SKILAK LAKE, LOOKING EAST FROM BILL KAISER'S CABIN.



THE RUSSIAN RIVER.

This stream rises in a clear-water lake, fed by the melting ice along the edge of the great Kenai Mountain glacier field. With its clear, rapidly flowing water it is typical of the mountain streams having their source in the lakes near the glacier. Large numbers of salmon ascend this river during the spawning season. Russian River has the reputation of being one of the best fishing streams in Alaska. The rainbow and Dolly Varden trout are the chief game fishes.



VIEW OF BARTLETT GLACIER.

of Montague Island is also parallel with the general trend of the rocks composing that island.

The most marked valley in this region is that which extends from the head of College Fiord through Port Wells, Cochrane Bay, and the upper stretch of Port Nellie Juan. This is a distance of 56 miles at sea level, and the depression is continued for an unknown distance to the northeast in the valley in which lies the Harvard Glacier, and also an unknown distance to the southwest of the head of Port Nellie Juan.

At a number of places in the eastern part of Prince William Sound there are fairly flat, low-lying islands, forelands, and valleys from which the mountains as a rule rise steeply. These flats are regarded as parts of an erosional surface which was developed not far above the present sea level. In height this surface is commonly 20 to 60 feet above tide, and there are a considerable number of areas which do not exceed 100 feet in altitude. Islands of this character, which have remarkably level surfaces, occur close to Rocky Point near the entrance to Galena Bay; and the Porpoise Rocks, near Nuchek, at the west end of Hinchinbrook Island, are also of this nature. The islands north and west of Bligh Island are likewise low. The lowland about the village of Tatitlek, south of Ellamar, belongs with this plain, as do also the forelands of Sheep and Bomb Points, on the north side of Cordova Bay, and parts of the north side of Hinchinbrook Island. One of the most characteristic forelands is the end of the point separating Landlocked and Fidalgo Bays. Among the valleys whose floors probably belong to this same plain is that extending from Boulder Bay northward to Galena Bay, also the valley running southward from Snug Corner Cove toward Knowles Head and the two valleys running southward from Bowie Bay.

An outline of the geology of Prince William Sound, as described by the same authors,[1] is given below:

The rocks of Prince William Sound are readily separable into those of sedimentary and those of igneous origin. To the igneous division belong (1) granites, (2) acidic dike rocks, (3) basic intrusive rocks, and (4) basic surface flows. The granites, which are mainly biotite granites, occur in several masses, the largest of which is that of Esther Island. They are intrusive into the surrounding rocks, which they have metamorphosed much less than is customary in areas of granitic intrusions. The acidic dikes are mainly aplitic in character, are not numerous, and are of small size. Dikes of quartz porphyry are known at two localities, on Unakwik Inlet and in the Nunatak of the Columbia Glacier. The aplite dikes cut the Valdez group and the quartz porphyry is perhaps later than the Orca. The basic intrusives are diabases, gabbros, and diorites; some of these are intrusive into the Orca rocks. Gabbro occurs in small amount and is known at two localities, on the northeast end of Latouche Island, where it intrudes the Orca sediments, and on Esther Island, where it is associated with granite. Diorite occurs as a phase of some of the granites, especially that on Culrose Passage. Dioritic rocks also occur as alteration phases of diabase and gabbro. The basic flows are commonly altered green igneous rocks and are conveniently grouped under the name of greenstone.

The sedimentary rocks of the sound show marked uniformity in lithology. They are mainly slates, gray to black in color, and graywackes. The latter term is used to include sediments of coarser grain than the slates, which

[1] Grant, U. S., and Higgins, D. F., Reconnoissance of the Geology and Mineral Resources of Prince William Sound, Alaska: Bul. No. 443, U. S. Geol. Survey.

closely resemble each other. The rocks vary, however, from graywackes to arkoses and even to sandstones and quartzites, but the term graywacke conveniently covers the whole. The sedimentary rocks are essentially without fossils and are in general closely folded but not highly metamorphosed.

The sedimentary rocks of Prince William Sound are separable into two divisions, known as the Valdez group and the Orca group. The Valdez is the older and outcrops along the northern part of the sound, especially on the shores of Port Valdez. This group is composed of slates and graywackes which have been closely folded and metamorphosed to some extent so that they are now partly crystallized. No markedly crystalline schists occur except in the vicinity of granitic intrusions. The Orca group lies unconformably upon the Valdez and has been much folded, though not as closely as the Valdez. The Orca group consists in the main of dark-colored slates and graywackes, with locally much greenstone; conglomerates and inconspicuous limestones occur in some places. The greenstones are to a large extent altered basic lava flows, interstratified with slates and graywackes. The peculiar ellipsoidal structure of these greenstones is a marked characteristic of parts of the Orca group. The Orca rocks occur especially on the eastern and southern shores of the sound and on the islands of the central part of the sound. The intrusive rocks of the district consist of basic dikes and bosses and dikes of granite. The basic dikes are apparently of Orca age, but some at least of the granites cut the Orca rocks.

The chief mineral deposits of Prince William Sound are copper ores. The ore mineral is chalcopyrite, with which pyrrhotite usually occurs. The ore deposits are mainly in shear zones in the greenstones or in the slates of the Orca group close to the greenstones. The important copper deposit on Latouche Island is, however, not known to be intimately associated with greenstone. There are two producing copper mines on the sound—the Ellamar mine at Ellamar and the Bonanza mines, on Latouche Island. Copper prospecting has been active, especially about Boulder, Landlocked, and Fidalgo Bays and on Knight and Latouche Islands.

The Valdez group was named by Schrader,[1] who studied these rocks about Port Valdez and to the north and east. Lithologically the group consists of slates and graywaches, commonly in narrow alternating bands.

North of Port Valdez this group of rocks extends to the northern shores of Lake Klutina, a distance of some 50 miles. On the east it extends to Copper River and up that stream to the mouth of the Chitina. South of the entrance to Port Valdez the Valdez rocks occupy the shores of Jack Bay and of the eastern part of Galena Bay, east of which their southern limit runs north of Copper Mountain. They possibly reach Fidalgo Bay, but from present knowledge this bay is thought more probably to lie in the Orca group. On the west side of Valdez Narrows, opposite the mouth of Jack Bay, the Valdez rocks are replaced for several miles by the slates and greenstones of the Orca group, but the older group reappears northeast of Point Freemantle, and from this point westward and southward to Port Bainbridge forms, with some granite masses, the main shore line of the sound.

From Point Freemantle westward to Esther Island the rocks along the headlands which separate the indentations in the coast line are, with the exception of granite, graywackes and slates. These are in many places highly brecciated.

[1] Schrader, F. C., A reconnoissance of a part of Prince William Sound and the Copper River district, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 408.

Conglomerates occur in a number of places, especially (1) on both sides of the entrance to Galena Bay, (2) on the north shore of Fidalgo Bay west of Fish Bay, (3) on the north shore of Orca Bay between Sheep and Simpson Bays, (4) on the northwest side of Latouche Island near the Bonanza mine, (5) near the northeast corner of Hoodoo Island, and (6) on the northwest side of Elrington Island.

Limestones are not common. They occur in small amount (1) north of the entrance to Galena Bay, (2) just north of Gravina Point, (3) on Cedar Bay on the north side of Hawkins Island, and (4) at the Banta shaft of the Reynolds-Alaska Development Co. on Latouche Island. At the first-mentioned locality limestone, or, rather, calcite, occurs as a cement to some of the coarse-grained fragmental rocks at the base of the Orca group. At the second locality are a few low exposures of finely banded, highly contorted, fine-grained siliceous limestone, which is red, gray, and green in color. At the third locality the limestone "consists of layers varying from 1 to 2 feet or more in thickness. It is compact or dense in texture and dark blue or black in color." At the fourth locality a number of blocks of coarse-grained limestone were found on the dump from a shaft about 100 feet deep. This limestone probably came from a bed near the bottom of the shaft. The rock is porous and contains grains of quartz and flakes of muscovite. Some black, calcareous bands have been found elsewhere in the slates and are probably more common than the field notes would indicate, for such bands are easily overlooked.

VEGETATION.

The flora of the Prince William Sound region differs markedly from the flora characteristic of Cook Inlet; it is more like that of the country between Seward and the head of Turnagain Arm, including as the principal trees spruce and hemlock. Alders are abundant, but they do not seem to occur in such frequent and dense belts as in the typical alder zone just above timber line in the Cook Inlet country. There is much less birch and black spruce here, and less low-bush cranberry; and a number of other plants common to Cook Inlet are not found here. There is not nearly so much native redtop, probably for the reason that there is not so much suitable open ground for it.

There is abundance of Muskeg or bog here, but the individual areas are not so large as the more important bodies of Muskeg in the Cook Inlet country. Here the Muskeg occurs on shelf situations, in depressions and even as slightly sloping areas on the mountain slopes. It consists of boggy peat made up principally of decaying moss, and supports a heather growth including a number of plants like those of the Cook Inlet Muskeg.

Except on the cliffs and steep rock outcrops, the lower slopes of the islands and mainland of Prince William Sound are timbered. In many places the forest is dense and the trees of large size, up to an apparent elevation of somewhat more than 2,000 feet above sea level. The density of stand and size of the trees varies considerably with

the character of the slope. On the steeper slopes where the soil is thin, where the rock outcrops in many places, and the tree growth is sparse, the average size is considerably smaller than in the forest of the less steep and rocky slopes.

The average forest growth of Prince William Sound is more dense than that of the Cook Inlet region; it is more like that of the slopes along the Government railroad between Seward and Kenai Lake. The trees also average considerably larger than those of Cook Inlet.

Owing to the very heavy precipitation of the sound region (see climate, pp. 9–30) and the usual saturated or moist condition of the forest mold, fires can do little damage here. Burned-over tracts like those of the Cook Inlet country were not seen.

SOILS AND AGRICULTURE.

From what has already been said in regard to the prevailing steepness of the slopes about Prince William Sound it can be seen that there are no very large areas of land having a surface favorable for farming. The forested slopes are mantled with soil from a few inches to a foot or more deep, it is true, but this is seldom found in situations sufficiently smooth for the carrying on of practical farming operations, and from an agricultural standpoint it can be classed, in the main, as mountainous or nonarable land.

There are scattered areas of smooth low country, usually not very large, such as that on the point between Landlocked and Fidalgo Bays and at Strawberry Point on Hinchinbrook Island. Some of the low-lying islands (see p. 137) embrace areas of land possibly of agricultural value, but much of that which at a distance appears as open grassy glades is Muskeg, with little or no value. There are flats on some of the streams, especially in their deltas, such as that at the head of Port Valdez, upon which the town of Valdez is built, that have some agricultural value.

The slope land of the Prince William Sound country consists principally of brown loam frequently containing small particles and larger fragments of the various underlying rocks. At the surface there is very often a dark-brown layer rich in decaying vegetable matter, and there is usually a covering of vegetable mold or moss and mold. The depth to bedrock is extremely variable, being greatest on the gentler lower slopes, in depressions and in shelflike situations. Most of the soil probably ranges in depth from about 2 inches to about 12 or 15 inches.

This soil is very much like the mountain-slope soil of the Cook Inlet region; that is, the Talkeetna loam. (See p. 79.) In situations favorable to cultivation, soil of this type would undoubtedly produce good crops of potatoes, grain, hay, grass, and vegetables.

The stream bottom or delta soils consist of gravelly, sandy, and silty alluvial material, mostly consisting of recent glacial outwash deposited by overflow water on the flats of the deltas below, as in the case at Valdez, where the outwash is from the near-by glaciers, Valdez, Corbin, Worthington, and others contributing water to the streams entering the head of Port Valdez. This soil is like the Susitna soils of Cook Inlet. (See pp. 83–87.) At Valdez there is much bluish gravel, gravel and sand, and some areas consisting of similarly colored silt loam over gravel and sand.

Some small patches of white clover, oats, and timothy were seen at Valdez, from which hay for the horses and cattle kept here was being cut. Fairly good yields are obtained. Cabbage, potatoes, and other vegetables, and currants, raspberries, and a variety of flowers were doing well in the gardens.

Opportunity for agricultural development in the Prince William Sound country is restricted to scattered and relatively small areas of land available for farming. At present farming is confined to a few small patches about the villages and settlements, the whole being of no great importance. Gardening, dairying, and cattle raising, in a small way, seem to be the most promising possibilities.

GENERAL DEVELOPMENT.

Mining of copper is the principal industry of the Prince William Sound region. There are several producing mines on the sound, as at Latouche, Ellamar, and Landlock. Cordova is the port from which the rich copper ore of the Kennicott mine in the Wrangell Mountains is shipped. This is the largest town on the sound. It is the Pacific terminus of the Copper River & Northwestern Railway, which extends to the Kennicott mine.

Cordova and Valdez, the principal towns on Prince William Sound, have populations of about 1,000 and 500, respectively. The Government wagon road from the coast to Fairbanks, in the interior of Alaska, begins at Valdez. This road is used by vehicles and automobiles over the entire distance of 367 miles from Valdez to Fairbanks. Valdez is the outfitting point for many of the prospectors and miners working in the Prince William Sound, Copper River, and Tanana districts.

Other settlements are at Orca, Landlock, Latouche, and Ellamar, and there is a military post at Fort Liscum, near Valdez. Indian villages are Nuchek, on the west end of Hinchinbrook Island; Tatitlek, near Ellamar; Kiniklik, on the north side of the sound between Unakwik Inlet and Eagle Bay; and Chenaga, in the southeastern part of Chenaga Island.[1]

[1] Bul. No. 443, U. S. Geol. Survey.

There are salmon canneries at Cordova and Orca, and clam canneries at Cordova.

THE COPPER RIVER DELTA.

The Copper River delta as here referred to comprises the lower delta or flats of Copper and Martin Rivers and the flats of the adjacent mountains and glaciers, extending from Orca Inlet, or the eastern end of Prince William Sound, eastward to Cape Suckling and Bering Glacier.

Much of this area is comprised in the alluvial flats of Martin and Copper Rivers and those of the glacier streams west of Copper River, the whole forming a continuous area of alluvial flats extending from about the eastern end of Eyak Lake nearly to Katella, on Controller Bay, with a shore line nearly 50 miles long. The apex of the delta is about 30 miles inland.

These flats are ramified by a network of main channels and distributaries or "sloughs," and there are many islands. They constitute essentially a treeless area, with here and there groves of spruce, alder, and willow. There is an abundance of slough grass (*Carex* sp.), goose tongue, and some redtop, beach rye, and other grasses, and many low bushes resembling myrtle. The delta is subject to overflow by streams, and the lower Mud flats along the ocean are covered by tides. There are many permanent lakes and also depressions that hold water much of the year. Between the lakes, pools, sloughs, and streams the grass-covered land is firm, and, while wet much of the time, some of it could be used for the production of vegetables and grain hay. Probably its best use, however, would be for pasturage.

The soil here is much like that of the Mud flats along Cook Inlet (see p. 88), but being apparently more an alluvial deposit, it probably should be considered deep Susitna silt loam. The soil seen consists of a bluish-gray silt loam that shows but little change downward, as far as examined, aside from an occasional streak of rusty brown in the subsoil.

The surrounding mountainous country probably has about the same soil condition as the slopes about Prince William Sound. It includes many large glaciers, as Bering, Martin, Sheridan, Scott, and Snyder. There is some timber on the lower slopes and, in places, on the adjacent flats between the glaciers.

The Bering coal field is near Katalla, and some development work has been done here. Work is now (1916) being done on a railroad. The Copper River & Northwestern Railway crosses the Copper River delta from Eyak Lake, passing between Childs and Miles Glaciers, near the head of the flats.

○

[PUBLIC RESOLUTION—No. 9.]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]

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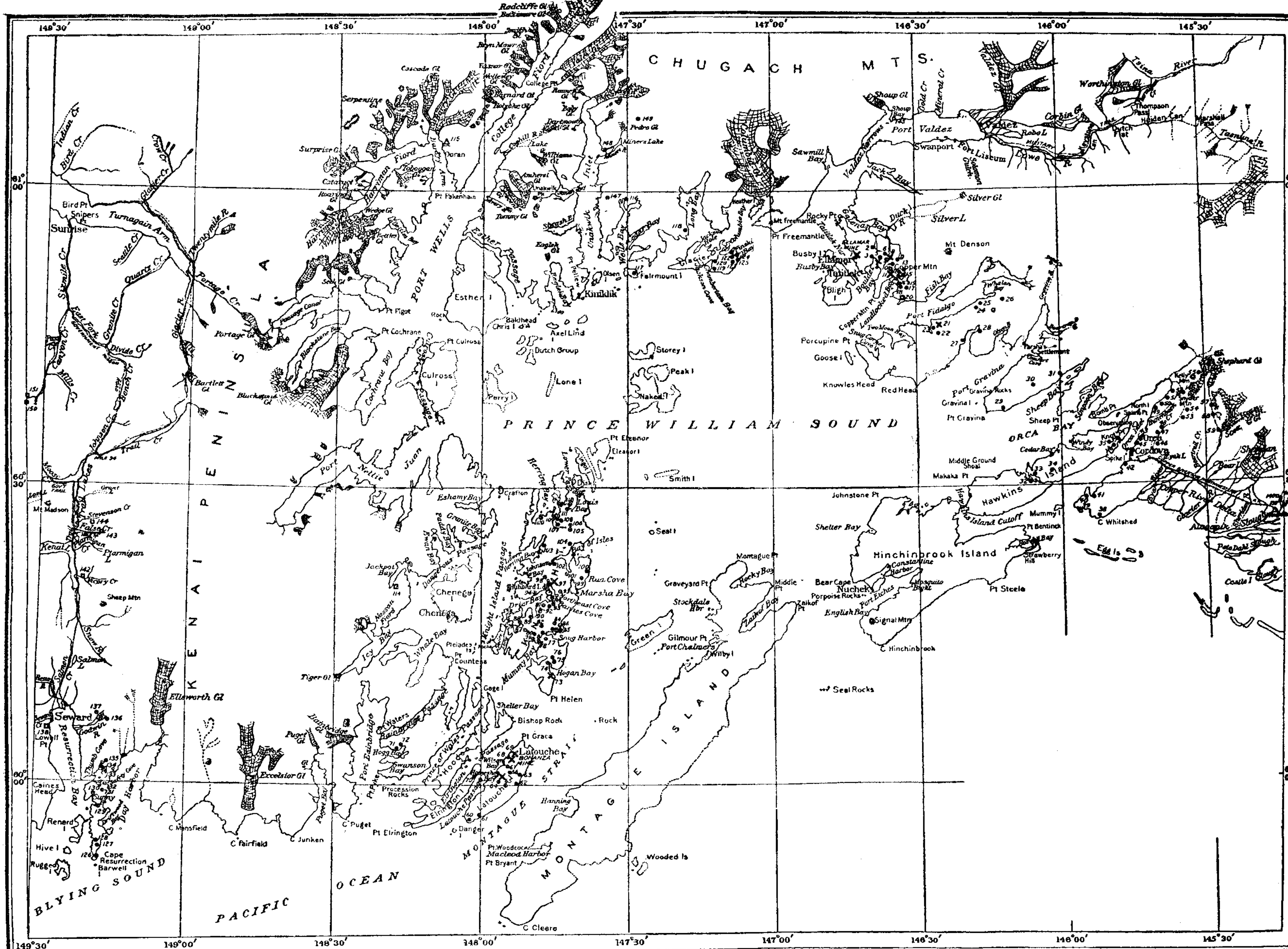
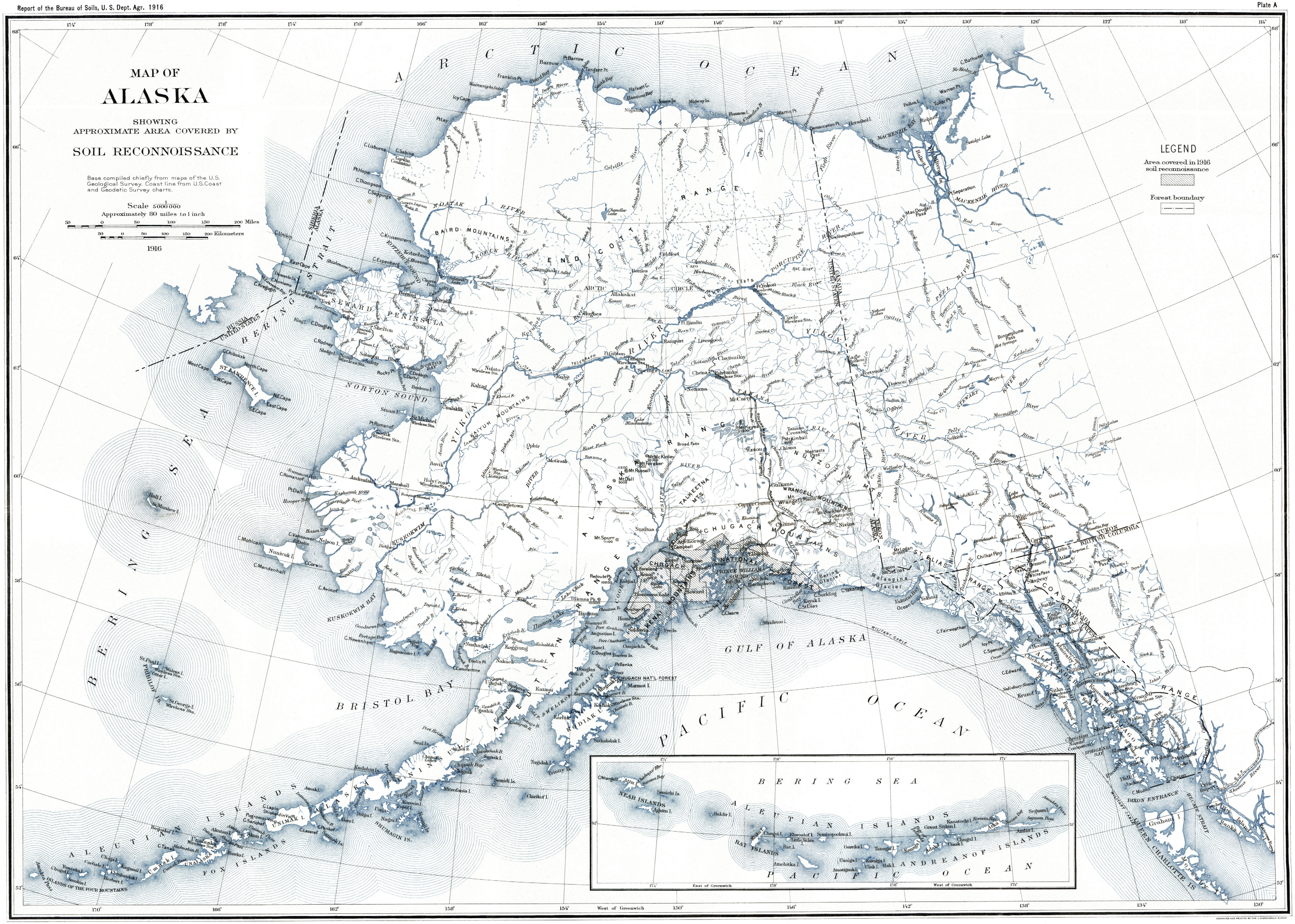


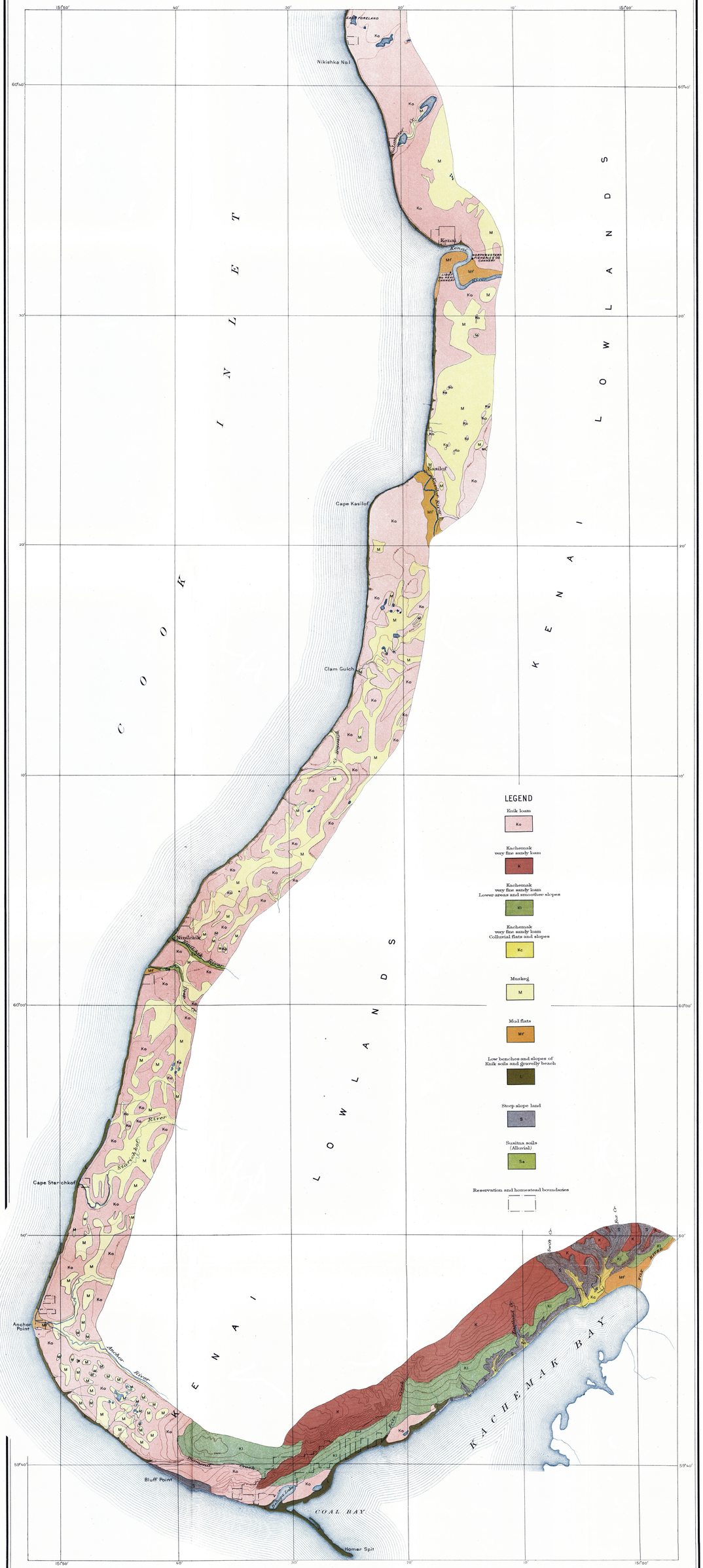
Fig. 1.—Map of Prince William Sound region.


MAP OF
ALASKA
SHOWING
APPROXIMATE AREA COVERED BY
SOIL RECONNOISSANCE
Base compiled chiefly from maps of the U.S. Geological Survey. Coast line from U.S.Coast and Geodetic Survey charts.
Scale 1/5000000
Approximately 80 miles to 1 inch
Miles
Kilometers
1916
LEGEND
Area covered in 1916 soil reconnoissance
Forest boundary
ARCTIC OCEAN
BERING SEA
BERING STRAIT
NORTON SOUND
BRISTOL BAY
GULF OF ALASKA
PACIFIC OCEAN
ALEUTIAN ISLANDS
SEWARD PENINSULA
ENDICOTT RANGE
ALASKA RANGE
CHUGACH MOUNTAINS
WRANGELL MOUNTAINS
ST. ELIAS RANGE
COAST RANGE
KUSKOKWIM BAY
PRINCE WILLIAM SOUND
CHUGACH NAT'L FOREST
DIXON ENTRANCE
West of Greenwich
East of Greenwich

U. S. DEPT. OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF.
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY.

SOIL MAP

ALASKA
KACHEMAK BAY-EAST FORELAND SHEET.



Soils by Hugh H. Bennett, of the Bureau of Soils, based on Forest Service Classification of lands by L. Wernstedt and A. Nilsson.

Scale of Miles
1 0 1 2 3 4 5 6 7 8 Miles

Contour interval 100 feet.

Field Operations Bureau of Soils 1916

U. S. DEPT. OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF
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SOIL MAP

ALASKA
RECONNOISSANCE SURVEY—KENAI PENINSULA SHEET

LEGEND

- Knik loam — Ko
- Knik loam including some Muskeg — B
- Knik loam and Muskeg probably about equal distribution — C
- Kachemak very fine sandy loam — K
- Kachemak very fine sandy loam lower areas and smoother slopes — Kl
- Kachemak very fine sandy loam Colluvial flats and slopes — Kc
- Probably mainly Kachemak very fine sandy loam including some Muskeg — Kv
- Muskeg — M
- Muskeg and Knik loam Muskeg probably predominating — A
- Mud flats — Mf
- Low benches and slopes of Knik soils and gravelly beach — L
- Steep slope land — S
- Susitna soils and recent gravelly and silty glacial outwash — Su

Dotted lines represent probable topography unsurveyed.

Note: The topography and the major portion of the coast line from Aialik Bay to Port Graham are from exploratory surveys and should not be considered absolutely accurate.

Soils by Hugh H. Bennett, L. Wermstedt and A. Nilsson.

BASE MAP FROM
U. S. GEOLOGICAL SURVEY SHEET 1915

Scale 1/250000
5 0 5 10 15 Miles
5 0 5 10 15 20 Kilometers
Contour interval 200 feet.
Datum is mean sea level.

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

Field Operations
Bureau of Soils
1916

U. S. DEPT. OF AGRICULTURE
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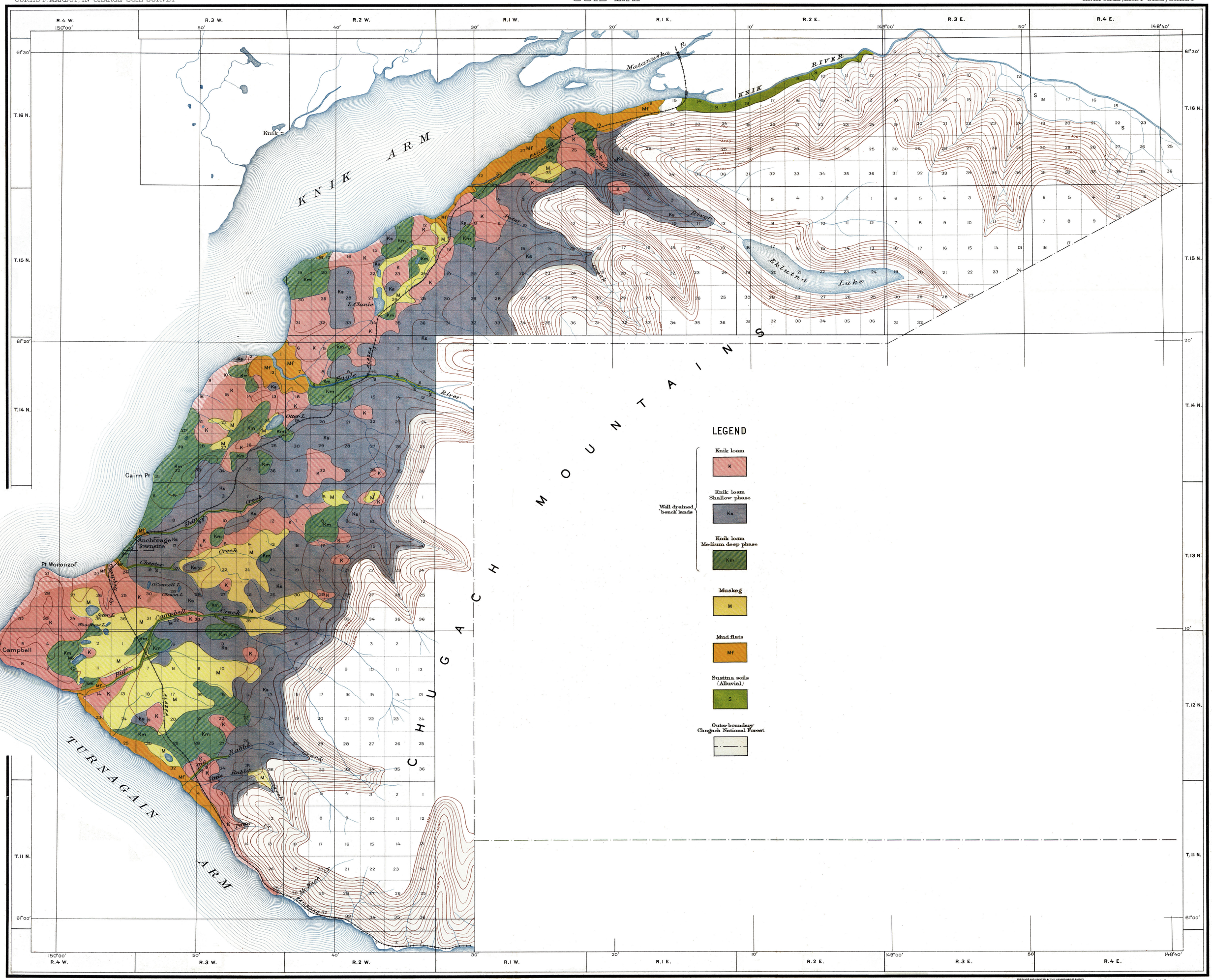
SOIL MAP

ALASKA
KNIK ARM (EAST SIDE) SHEET



LEGEND

- Knik loam — K
- Knik loam, Shallow phase — Ks (Well drained bench lands)
- Knik loam, Medium deep phase — Km (Well drained bench lands)
- Muskeg — M
- Mud flats — Mf
- Susitna soils (Alluvial) — S
- Outer boundary Chugach National Forest

Soils by Hugh H. Bennett, of the Bureau of Soils, based on forest Service classification of lands by Thos. M. Hunt and Asher Ireland.

Scale of Miles
1 0 1 2 3 4 5 6 7 8 Miles

Contour interval 100 feet.

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1916